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CONTENTS.

PAGE

Fifth Catalogue of Micrometrical Measures of Double Stars, made at the Temple Observatory, Rugby. By G. M. Seabroke, A. P. Smith, and H. P. Highton 1

Observations of the Spectra of Sun-spots in the Region B—D, made at the Stonyhurst College Observatory. By Rev. A. L. Cortie, S.J. 29

Measures of Double Stars made at Sydney Observatory in the Years 1882–89. Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer 57

Double-Star Observations, 1888–91. By W. H. Maw 75

On the Construction of a Five-foot Equatorial Reflecting Telescope. By A. A. Common, LL.D., F.R.S. 113

Fifth Catalogue of Micrometrical Measures of Double Stars, made at the Temple Observatory, Rugby. By Geo. M. Seabroke, A. Percy Smith, and H. P. Highton.

[Received April 1; read April 11, 1890.]

The following observations are in continuation of similar lists presented to the Society by the Rev. J. M. Wilson, Mr. Percy Smith, and myself, and printed in vols. xlii., xliii., xlvi., and xlviii. respectively, and are largely repetitions of measurements of the stars contained in such lists, with some additions.

The earlier measures of this series are made chiefly by Mr. Seabroke, but of late he has been engaged on another line of research, and the more recent ones are entirely due to Mr. Percy Smith or Mr. Highton, who has succeeded him at this observatory.

We have as far as possible taken four measures of position and two double measures of distance of each star.

The instruments used are the $8\frac{1}{4}$-inch refractor and bifilar micrometer. A Barlow lens is used in such a position that ten divisions on the head of the screw correspond very approximately to $1''$ of arc.

The R.A. and Dec. are reduced where possible from Herschel's Catalogue, and the magnitudes are chiefly from Struve and O. Struve.

In the following list S.=Seabroke, Sm.=Percy Smith, and H.=Highton.

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
10308		3063	8½, 10	0 1·5	− 5 12	224	4			84·95	S.	Too faint for distance.
2	316 B Cephei	2	6½, 6½	2·7	79 2	150·4	1			86·09	S.	
35	AB	[2]	7, 8, 9½	7·5	26 20	47·2	4	0·7	est.	84·07	S.	
						48·1	6			·08	S.	
	AC					228·0	3			84·06	S.	
						226·7	4	17·45	2	·07	S.	
						225·9	4			·08	S.	
						227·8	4			·93	S.	
59		[4]	7½, 8	10·5	35 48	359·7	3			84·06	S.	Elongated
						360·3	4			·07	S.	
						358·7	5			·08	S.	
87		21	7½, 9½	13·7	37 34			62·73	3	84·06	S.	
						17·4	2	63·03	3	·07	S.	
						17·7	2	63·1	2	·08	S.	
164		[13]	7½, 10½	25·4	36 16	131·9	4	11·88	2	84·07	S.	
						132·1	4	11·68	2	·08	S.	
						130·0	2	11·55	2	·92	S.	
						132·2	2	11·61	2	·92	H.	
242		[18]	7½, 9½	36·1	3 31	104·5	1			84·93	Sm.	Doubtful.
						110·0	4	1·2	est.	84·93	S.	
						118·1	4	1·34	1	·95	S.	Dist. est. with wires.
249		[19]	7½, 10½	37·2	36 54	111·9	4			84·07	S.	
						112·4	4			·08	S.	Too faint for distance.
						108·8	4			·93	S.	
251		52	8, 9	37·5	45 35	17·5	4	1·24	2	84·06	S.	
						20·7	4	1·5	2	·07	S.	
						18·6	4	1·47	2	·08	S.	
						22·3	4	1·24	2	·10	S.	
						20·6	4			·93	S.	

283	24 Cassiopeiæ, η	60	4, 7½	41·7	57 11	172·8	4	5·27	2	85·23	S.	
						176·0	4	4·8	2	86·09	S.	
						177·6	4	4·75	2	·24	S.	
						176·2	4			·26	Sm.	
						180·6	4	4·6	1	87·35	Sm.	
						181·3	4	4·6	1	88·07	S.	
						181·3	4	4·79	2	·90	H.	
						184·35	4	4·49	2	89·09	S.	
						186·3	4	5·0	2	·10	H.	Hazy.
						187·0	4	4·43	2	·12	S.	
295		63	8, 11	43·9	11 10	226·0	3			85·87	Sm.	Very faint.
						228·7	5			·90	Sm.	Barely visible.
297		64	9, 9½	44·5	40 38	273·9	4	4·48	2	84·07	S.	
						275·1	4	4·21	2	·08	S.	
						276·2	5	4·48	2	·10	S.	
305		67	8½, 9	45·8	9 57	7·5	2			84·12	S.	Doubtful.
						3·5	1			·93	Sm.	A mere guess.
						5·7	4	1·25	2	·93	S.	
316	66 Piscium	[20]	6, 7	48·2	18 32	15·8	4	0·5	est.	84·08	S.	
						19·2	5	0·5	est.	·12	S.	Elongated only.
						28·5	9			·13	S.	V. doubtful; readings vary through 17°.
										·95	S.	Round.
320		74	8, 9	48·5	8 46	297·7	4	4·14	2	84·93	S.	
						303·8	5	3·27	2	·95	S.	
354		[21]	7½, 8½	56·1	46 44	181·3	1			84·95	Sm.	
						180·6	3	1·0	est.	·95	S.	
378	74 Piscium, ψ^1	88	5, 5	59·2	20 50	159·9	2	29·65	3	84·08	S.	
						159·7	1	29·77	2	·12	S.	
377		87	8½, 8½	59·2	14 45	196·5	4	6·41	2	84·93	S.	
						197·3	4	6·58	2	·95	S.	
	φ Andromedæ	[515]	5, 6½	1 2·4	46 36	260·3	4			84·95	S.	
453	AB	102	7, 8, 8, 10	10·7	48 23	296·2	4	0·5	est.	84·12	S.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
453	φ Andromedæ AB (*continued.*)					299·1	5			84·13	S.	
						301·6	4			·14	S.	
	AC					223·4	4	10·10	2	84·12	S.	
						225·0	2	10·06	2	·13	S.	
						224·4	4	9·93	2	·14	S.	
	AD					63·7	3	27·73	2	84·12	S.	
515		125	8, 10½	1 20·8	0 45	348·0	3	30·8	1	85·90	Sm.	
543	219 B Andromedæ AC	133	7, 10½, 10	25·9	35 13	196·5	3	25·94	2	84·12	S.	
			10, 9, 9½			196·1	2	25·95	2	·14	S.	
						196·1	1	25·25	1	·95	S.	
	AD					192·1	3	30·44	2	84·12	S.	
						192·0	2	30·92	3	·14	S.	
	CD					347·7	3	6·0	est.	84·12	S.	
						351·4	4	5·37	2	·14	S.	
						351·5	4			85·90	Sm.	Of little value.
	AB					189·8	4	3·5	1	84·14	S.	
						187·2	4	3·13	2	·95	S.	
	AE					0·2	2	160·0	est.	84·14	S.	Distance by direct reading only.
	AF					351·0	3	180·9	est.	84·14	S.	
	EF					301·0	2	33·03	2	84·14	S.	
564		[33]	7, 8	29·5	58 2	75·6	3	24·39	2	84·12	S.	
						77·0	4	24·38	2	·14	S.	
						76·5	4			·16	S.	
611	251 Ceti, χ^1 (B)	147	5½, 7	35·8	−11 56	88·0	4	3·52	2	84·95	S.	
						88·1	4	3·16	1	85·90	Sm.	Definition very bad.
694	γ Arietis	180	4½, 4½	46·9	18 42	0·9	4	8·37	2	84·16	S.	
						359·6	4	8·35	2	·18	S.	
						359·5	2	7·83	1	85·90	Sm.	
704	AC	183	7½, 8, 8½	48·4	28 13	163·3	4	5·67	2	84·13	S.	

						165·5	4	5·22	2	·16	S.		
						164·2	5			·19	S.		
	AB					26·2	4			84·13	S.		
						12·7	4			·16	S.		
						16·6	2			·19	S.	Too close for distance.	
738	AC	196	9, 11, 10, 6½	52 8	28 26	167·1	1			87·08	Sm.		
						172·5	2			·10	Sm.		
	AB					61·0	3			87·10	Sm.		
						54·5	1			·12	Sm.	Valueless.	
740		197	7½, 8½	54	34 42	229·9	4	23·66	2	84·13	S.		
						234·2	4	23·14	3	·16	S.		
						233·9	4	23·78	3	·19	S.		
755	57 Andromedæ, γ^2	[38]	5, 6	56·5	41 46	113·7	3			84·16	S.	Slightly elongated.	
						113·3	5			·18	S.		
						113·7	3			·19	S.	Doubtful.	
818	259 B Andromedæ	228	6½, 7½	2 6·3	46 55	349·6	5	0·95	1	84·2	S.	Elongated only.	
						358·5	6			·21	S.		
						354·3	5			·22	S.	Doubtful.	
						7·5	1			85·23	S.		
						359·6	3			86·09	S.		
						5·6	2			·24	S.		
						2·3	1			89·09	S.		
						20·6	1			·12	S.	?	
						335·0	1			·83	H.	? in contact.	
836		236	8½, 9½	9·	51 55	262·0	3			84·13	S.	Slightly elongated.	
										·16	S.	Round.	
										·18	S.	Round.	
852		240	7½, 8½	10·4	23 19	50·5	3	4·62	2	84·16	S.		
						52·3	4	5·65	2	·18	S.		
						49·3	4	5·47	2	·19	S.	Hazy.	
875	o Ceti		A 2½–9½	13·3	− 3 30	81·6	2	109·10	1	87·08	Sm.		
			B 9½			86·2	2	110·25	1	·10	Sm.	Good definition.	
						80·2	4	109·84	2	89·83	H.	Careful readings.	

Herschel's Number.	Name of Star.		Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
					h m	° ′	°		″				
880			[40]	7½, 8½	2 14·3	37 57	52·9	3			84·16	S.	Elongated.
							57·1	3			·20	S.	Doubtful.
							56·6	3			·21	S.	
906	ι Cassiopeiæ	AB	262	4, 7, 7½	19·1	66 52	262·8	4	2·02	2	84·16	S.	
							261·7	2	1·84	1	·16	Sm.	
							261·1	4	2·47	2	·18	S.	
		AC					110·8	4	7·59	2	84·16	S.	
							110·7	2	7·29	1	·16	Sm.	
							112·0	4	7·05	2	·18	S.	
995			[44]	7½, 8½	34·5	42 10	53·4	4	1·26	2	84·16	S.	
							53·5	5	1·20	1	·19	S.	
1020			300	8, 8½	37·5	28 55	303·9	4	2·72	2	85·13	S.	
							303·8	4	3·12	2	·15	S.	
							305·2	4	2·72	2	·17	S.	
1047		AB	311	5, 8½, 10	42·4	16 58	121·4	4	3·18	2	85·13	S.	
							122·2	4	3·10	2	·17	S.	
		AC					110·7	2	25·0	est.	85·13	S.	
1084			328	8½, 9	49·8	44 2	300·3	4	22·4	2	85·13	S.	
							300·0	4	22·5	2	·17	S.	
1104			334	7½, 8	53·0	6 10	322·3	4	1·12	2	85·13	S.	
							319·8	4			·15	S.	Very low down.
							323·3	4			·17	S.	
1108			[49]	7, 10	53·8	17 32	61·7	3			85·17	S.	
							61·5	4			·19	Sm.	
1109			336	6½, 8	54·1	31 56	9·2	4	8·48	2	85·17	S.	
							8·8	4	8·35	2	·19	S.	
1129	52 Arietis	AB	346	6, 6, 10½	58·4	24 47	265·7	4	·70	est.	85·17	S.	
							263·1	6			·19	S.	
							271·7	4			·19	Sm.	

						275·2	4			·19	Sm.	
						277·0	1			·19	S.	
	AC					355·4	3			85·17	S.	
1188		[53]	7, 8	3 9·9	38 11					84·16	S.	Round.
						260·1	1			87·08	Sm.	A mere guess; elongated.
						254·5	3	·75	est.	·10	Sm.	Perfectly divided.
						249·5	3			·12	Sm.	Very shaky; clearly divided.
1224		381	7, 8½	16·4	20 32	107·4	3			84·16	S.	
						102·2	5			·19	S.	Elongated.
						103·8	4			·20	S.	
1240	9 Cameleopardi	388	8½, 9½	20·0	50 0	210·0	4	2·62	2	84·16	S.	
						208·5	4	3·43	2	·19	S.	
						206·9	4	3·64	2	·20	S.	
1271		403	8½, 8½	24·3	19 22	181·4	4	2·98	2	84·16	S.	
						180·2	4			·19	S.	
								3·01	1	·20	S.	
						176·1	4	2·69	2	85·17	S.	
						179·1	3	2·91	2	·19	S.	
1291		414	8, 8	27·7	19 25	185·3	4	7·74	2	84·16	S.	
						182·8	4	7·01	3	·19	S.	
						182·3	4	8·09	2	·20	S.	
1370		447	8, 9	40·1	37 58	171·6	4	26·87	2	84·16	S.	
						170·1	2	27·27	3	·19	S.	
						170·7	4			·20	S.	
1406	Cephei 49 Hev.	460	5, 6	50·0	80 22	37·8	4	– 1·0	est.	86·26	Sm.	
1409		[67]	5, 8½	46·9	60 45	46·5	4	2·02	2	84·16	S.	
						45·1	5	2·22	2	·19	S.	
						44·5	4	1·61	2	·20	S.	
1470		483	8, 9½	56·2	39 11	359·6	6			84·16	S.	
						349·9	4			·19	S.	
						357·4	5			·20	S.	
						356·5	5			·20	S.	Very faint.

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
1483		[71]	7, 9	3 59·2	33 6	210·7	4	·77	2	84·16	S.	
						211·0	3			·19	S.	
						209·6	4			·20	S.	
1486		[531]	6½, 8	59·5	37 45	139·8	4	2·12	2	85·19	S.	
						138·5	4			·19	Sm.	
						138·7	2	2·69	2	·23	S.	
1500		[72]	6, 9½	4 1·1	17 1	326·7	5			85·19	S.	
						326·0	1			·19	Sm.	Exceedingly faint.
						325·0	1			·23	S.	Too faint for illumination.
1521		[74]	8, 8½	5·7	9 20	283·2	2			85·19	S.	
						270·0	1			·19	Sm.	If anything.
										·23	S.	Failed.
										86·12	Sm.	Failed.
1528		511	7½, 8	7·9	58 29					86·26	Sm.	Failed.
1553	40 Eridani AB	518	4, 9	10·2	− 7 47	105·7	3	81·56	3	84·21	S.	
						105·1	1	82·39	2	·22	S.	
1602		[82]	7, 9	16·9	14 46	180·0	1			85·19	Sm.	Doubtful; def. v. poor
										·23	S.	Failed.
						162·0	1			86·12	Sm.	Very uncertain.
1592		531	7½, 8½	17·1	55 22	295·8	4			86·26	Sm.	
						304·5	1			·27	Sm.	
1595	56 Persei	[81]	6, 8½	16·8	33 40	227·3	4	4·46	2	85·19	S.	
						227·7	2			·19	Sm.	
1631		547	8½, 11½	20·4	− 1 40	5·5	1	5·0	est.	87·11	Sm.	Very uncertain.
										·12	Sm.	Failed.
1648	80 Tauri	554	5, 8	23·3	15 22	5·3	3			83·16	Sm.	Very uncertain.
										·23	S.	Failed.
										87·11	Sm.	Failed.
1677		[85]	7½, 10	28·1	48 9					85·23	S.	Failed.

						23·0	1			87·11	Sm.	Beyond our power.
1690		567	8½, 9	29·5	19 14	313·6	4	2·04	1	85·23	S.	
						315·5	2			87·11	Sm.	Very faint.
						318·2	2			·12	Sm.	Very faint.
1819		[90]	7, 9	48·4	8 24	339·1	3	1·94	1	85·23	S.	
						345·6	2			87·11	Sm.	
						345·7	3			·12	Sm.	
1834		[91]	7, 7½	49·9	3 0					85·23	S.	Failed.
						230·0	1			87·12	Sm.	Elongated.
						234·2	1	·5	est.	·15	Sm.	Almost divided; very difficult.
1849		622	8½, 8½	51·9	1 29	161·9	4	2·71	1	85·23	S.	
						171·3	2	2·27	4	87·12	Sm.	
						174·0	1			·15	Sm.	
						175·3	3			·16	Sm.	
		[93]	9½, 9	54	4 55	53·3	1			87·12	Sm.	Elongated only.
						51·2	4	·50	est.	·16	Sm.	Very difficult.
1897		[95]	6½, 7½	58·4	19 38	334·9	4	·90	est.	86·27	Sm.	Doubtful.
						336·8	4	·90	est.	87·12	Sm.	Beautiful double; clearly divided.
						334·2	3			·16	Sm.	
1923	14 Orionis, ι	[98]	6, 6½	5 1·3	8 20	204·3	3			85·23	S.	
						198·4	2	1·0	est.	87·12	Sm.	Very good definition.
						185·7	3			·16	Sm.	
1941		[100]	7, 10	3·5	8 1	250·5	4	4·02	1	87·12	Sm.	B very faint.
1947		651	8, 10	4·1	− 7 12	53·8	4	17·43	2	83·16	S.	
						54·4	6	17·93	2	·16	S.	
						51·9	5	17·59	2	86·09	S.	
						54·3	4	17·35	2	88·90	H.	Star low down; bad definition.
						49·5	4	16·77	2	89·09	S.	
						52·4	4	16·2	2	·12	S.	
						52·6	2	16·09	1	·12	H.	
						49·75	2	14·90	1	·83	H.	
1961	14 Aurigæ AB	653	5, 6½, 11	7 6	32 32	227·0	2	13·50	1	86·27	Sm.	? A double.
						226·5	2	13·70	1	·27	Sm.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
1991	λ Aurigæ	[545]	$5\frac{1}{2}$, $8\frac{1}{2}$	h m 5 10·5	° ′ 39 59	° 11·5	1	″		86·27	Sm.	
						10·5	1	120·0	1	·27	Sm.	
2097		715	$8\frac{1}{2}$, $8\frac{1}{2}$	21·8	41 10	202·0	1	·80	est.	86·27	Sm.	Barely visible as a double.
						207·7	1			87·16	Sm.	Very difficult.
2105	AB	719	7, $9\frac{1}{2}$, $8\frac{1}{2}$	22·3	29 30	332·0	1	·50	est.	86·27	Sm.	
	$\frac{A}{B}$C					350·5	1	12·6	1	86·27	Sm.	
						350·7	1			87·16	Sm.	
2428		[132]	$6\frac{1}{2}$, 10	6 0·0	37 59	320·7	5	1·74	1	84·20	S.	Distance estimated with wires.
						326·6	3			·21	S.	
						320·6	4			·22	S.	
2439		[133]	7, 10	0·8	21 19	32·7	4			84·20	S.	Too faint for distance reading.
						36·7	2			·22	S.	
						30·6	1			·24	S.	
						34·6	3			·25	S.	
2462		853	$7\frac{1}{2}$, $8\frac{1}{2}$	2·5	11 41	351·5	4	27·60	2	84·20	S.	
						350·1	3	26·97	2	·21	S.	
						350·2	4	26·72	2	·22	S.	
						350·6	1			·22	St.	
2473		859	8, $8\frac{1}{2}$	3·3	5 40	247·0	2	29·70	4	84·21	S.	
						245·3	6	30·77	2	·22	S.	
						245·8	1			·22	St.	
						247·3	4	29·73	2	·24	S.	
2475	Aa	861	$7\frac{1}{2}$, $8\frac{1}{2}$, $8\frac{1}{2}$	3·8	30 46	69·1	3	·50	est.	84·21	S.	? A seems double.
	BC					315·2	5	1·69	1	84·21	S.	
						320·8	4	1·74	2	·25	S.	
						316·1	4			·26	S.	
	A $\frac{B}{C}$					17·7	1	65·12	2	84·21	S.	
						14·8	4	65·23	2	·25	S.	

						17·9	4			·26	S.	
2650	11 Monocerotis AB	919	5, 5½, 6	22·9	− 6 57	131·3	4	7·40	2	84·26	S.	
	BC					104·9	4	2·68	2	84·26	S.	
	AC					124·8	4	5·47	2	84·26	S.	
2658		[143]	7, 10	24·3	17 1	104·6	4	7·88	2	84·25	S.	
						100·8	5	7·78	1	·26	S.	B extremely faint.
						100·0	5	8·27	1	·30	S.	
2700		935	8½, 9	28·9	52 24	325·5	4	4·39	2	84·25	S.	
						323·3	4	4·14	2	·26	S.	
						325·6	4	3·37	2	·30	S.	
2707		[149]	6½, 9	28·9	27 23	313·3	3			84·26	S.	Very difficult.
						297·3	4			·30	S.	
2710		941	7, 8	30·2	41 41	80·7	4	2·06	2	84·26	S.	
						81·1	4	1·90	2	·30	S.	
						80·8	4	2·00	2	·30	S.	
2717		943	8½, 9	30·3	23 19	146·2	3	19·68	2	84·26	S.	
						145·5	4	19·81	2	·30	S.	
2730		945	7, 8	31·9	41 4	267·1	4	1·01	2	84·26	S.	
2963		1016	8, 10	59·0	− 11 21	151·1	4			86·17	Sm.	
2985		[165]	5, 10½	7 1·5	16 8	175·8	4	1·96	1	84·30	S.	
2068		[170]	7½, 7½	11·2	9 31	118·0	4	1·47	2	84·30	S.	
3103		1074	8. 8	14·3	0 37	151·1	4	·70	est.	86·17	Sm.	
						131·8	4	·70	est.	·26	Sm.	
						151·5	1			·27	Sm.	
3138		[171]	7, 10	19	31 52	136·4	4	1·24	2	84·30	S.	
3214		1104	6½, 8½	23·9	− 14 44	322·0	4			86·26	Sm.	Not reliable.
3228	α Geminorum (Castor)	1110	2½, 3½	26·9	32 9	234·8	4	5·61	2	81·35	S.	
						234·5	4	5·41	2	·36	S.	
						234·8	5	5·78	2	82·23	S.	
						234·1	4	5·57	2	·25	S.	
						232·9	4	4·61	2	84·22	S.	
						231·6	1			·22	St.	
						233·1	3	5·40	4	·24	S.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
3228	Castor (*continued.*)					233·3	4			·38	S.	
						232·0	4	4·92	1	86·17	Sm.	
						232·4	4	5·23	2	86·24	S.	
						232·6	3	5·27	1	·25	Sm.	Very careful distant reading.
						232·7	4	5·53	2	87·35	S.	
						231·5	3	5·10	2	·35	Sm.	
						230·0	3			·35	Sm.	
						229·5	2	5·12	2	88·20	Sm.	Very shaky.
						231·0	2	5·02	2	·21	Sm.	
						230·5	4	5·09	2	·33	Sm.	
						230·7	4	5·07	2	·33	Sm.	
						231·3	2	4·80	1	89·09	S.	
						228·8	2	5·00	2	·09	H.	
						230·4	4	5·27	2	·10	H.	
						230·8	4	4·96	3	·12	S.	
						229·6	4	5·19	1	·12	H.	
						226·0	4	5·3	2	·83	H.	Very unsteady.
3557	ζ Cancri AB	1196	5, 5½, 5½	8 5·11	18 0	66·0	1			84·38	S.	
						67·8	5			·38	Sm.	
						59·5	2			·39	Sm.	
						59·3	4	1·26	1	85·23	S.	
						58·7	4	1·24	1	·32	S.	
						51·2	4	1·06	2	86·24	S.	
						51·7	4			·25	Sm.	
						47·8	4	1·21	2	87·35	S.	
						42·5	1			·35	Sm.	Mere guess.
						42·0	1			·35	Sm.	Too low to divide AB.
						51·7	2			·37	Sm.	Well divided.
						46·3	3			88·19	Sm.	Very unsteady.

						50·9	4			·32	Sm.	
						50·5	4			·33	Sm.	
						44·4	4	1·12	2	89·12	S.	
						45·1	4	1·30	2	·12	H.	
						38·6	4	1·19	2	·227	H.	? Cloudy; no definition.
	AC					39·9	4	1·20	2	·23	H.	
						127·1	4			84·38	S.	
						123·3	5			·38	Sm.	
						125·9	2			·39	Sm.	
						125·8	4			·39	Sm.	
						121·7	2	5·85	1	85·23	S.	
						122·5	4	6·06	1	·32	S.	
						122·1	4	5·23	2	86·24	S.	
						123·0	4	4·78	1	·25	Sm.	
						120·9	4	4·66	2	87·35	S.	
						120·5	2	4·88	1	·35	Sm.	
						120·0	2	4·70	1	·37	Sm.	
						119·0	2			88·19	Sm.	Very unsteady.
						120·9	4	4·75	2	88·32	Sm.	
						121·5	4	4·80	2	·33	Sm.	
						120·4	4	4·94	2	89·12	S.	
						119·0	4	5·10	2	·12	H.	
						120·4	4	5·70	2	·23	H.	
						116·7	4	4·60	2	·23	H.	? Zero probably shifted. Readings vary.
3646		1216	7, 7½	15·2	− 1 13	154·8	1			86·26	Sm.	Very doubtful.
										·26	Sm.	Failed.
						178·5	1			·27	Sm.	Very doubtful.
3680	ϕ^2 Cancri	1223	6, 6½	19·5	27 19	217·2	4	4·70	2	84·35	S.	
						216·9	4	5·15	2	·38	S.	
3868	ϵ Hydræ	1273	4, 8	40·3	6 52	224·9	4	2·63	2	86·26	Sm.	
						226·0	4	2·85	1	·26	Sm.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
3877		1281	7½, 8	8 41·4	0 28					85·35	S.	Companion not seen.
						318·2	4	33·2	1	88·32	Sm.	
						317·5	4	32·85	1	·33	Sm.	
						316·0	4	33·2	1	·33	Sm.	
3920	σ^2 Cancri	1291	6, 6½	47·9	31 2	329·9	4	1·46	2	84·35	S.	
						329·9	4	1·00	2	·38	S.	
						328·0	4	1·60	2	89·10	H.	
3947		1296	8½, 9	51·8	35 25	76·6	4	2·62	2	84·35	S.	
						74·6	5	2·10	1	·38	S.	
						76·6	4			·38	S.	
4046		1321	7½, 7½	9 6·5	53 13	61·5	5	19·77	2	84·38	S.	
						61·5	4	19·68	2	·38	S.	
4083		3121	7½, 7·8	10·7	29 8	31·4	5	·40	est.	81·26	S.	
						38·8	4	·40	est.	82·25	S.	
						32·6	4	·30	est.	·29	S.	
										86·24	S.	Elongated only.
										88·32	Sm.	Failed.
										89·12	H.	Scarcely elongated.
4084		1333	6½, 6½	11·0	35 51	44·3	4	1·64	2	84·38	S.	
						45·7	4	1·45	2	·38	S.	
						46·0	4			·39	Sm.	
4123		[200]	6½, 8½	16·6	52 5	337·5	6	1·6	1	84·38	S.	
						338·6	4	1·97	1	·38	S.	
						339·0	4			·39	S.	
4128		[201]	7½, 9	16·8	28 24	227·1	4	1·00	est.	84·39	S.	
						227·5	5			·40	S.	
4165	ω Leonis	1356	6, 7	23·0	9 34 46	87·2	4			84·38	S.	
						88·3	6	1·0	est.	·39	Sm.	
						82·3	5	1·0	est.	·39	S.	

						88·9	4	1·00	est.	85·35	Sm.	
						92·9	4	1·19	2	86·24	S.	
						87·3	4			·25	Sm.	
						94·0	2			87·37	Sm.	In daylight; 3 hrs. W.
						91·7	4			88·22	Sm.	Touching.
						92·5	4			·23	Sm.	
						90·7	4			·33	Sm.	
						94·1	4	0·70	1	89·19	H.	Doubtful.
4190	134 B Hydræ	1365	7, 8	25·3	2 0	163·2	4			85·35	Sm.	Very faint.
						163·9	4	3·24	2	88·32	Sm.	
						162·5	4	3·24	2	·33	Sm.	
						161·5	4	3·44	2	·33	Sm.	
						160·2	4	3·50	2	89·19	H.	
4314	8 Sextantis	AC 5	6, 6½	46·5	− 7 32	43·9	1			85·32	S.	Very doubtful.
										86·25	Sm.	Failed.
										·26	Sm.	Failed.
										88·32	Sm.	Failed.
						123·5	4			89·19	S. & H.	Only slightly elongated; position very doubtful.
4359		[210]	7⅓, 8½	55·1	46 57	271·1	6			84·39	S.	
						265·8	5	1·08	2	·39	S.	
						271·5	5			·40	S.	
4387		1406	8, 8½	58·7	31 40	233·6	2			84·38	S.	Uncertain.
						234·2	4	·90	est.	·39	S.	
						235·4	3			·40	S.	
4429		[213]	7½, 9½	10 6·5	28 1	114·3	3			84·39	S.	Very doubtful.
						120·3	4			·40	S.	
										85·35	Sm.	Failed.
4449		[215]	7, 7¼	9·7	18 20	218·0	1			85·35	Sm.	
						218·8	1	·92	1	·35	S.	
4469	γ Leonis	1424	2, 3½	13·3	20 27	113 2	4	3·25	1	86·26	Sm.	
						114·1	4	3·40	1	·40	Sm.	
						114·3	4	2·78	1	·42	Sm.	
						113·4	4	3·70	2	89·17	H.	

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4497		1428	7½, 7½	h m 10 18·4	° ′ 53 14	° 87·9	4	″ 3·21	1	85·35	Sm.	
						87·9	4			·41	Sm.	
4513		[217]	7½, 7½	20·4	17 49	149·7	4	·80	est.	85·35	Sm.	
						148·7	4			·41	Sm.	
4613		[225]	7½, 10	33·5	19 51	356·0	4			85·35	Sm.	Very faint.
						353·9	4			·41	Sm.	Very faint.
4628		1465	8½, 8½	36·2	45 15	11·6	4			85·41	Sm.	
						13·2	4			88·32	Sm.	Too faint for distance.
						13·0	4			·33	Sm.	
						13·2	4			·33	Sm.	
4669		1472	7½, 8½	40·6	13 36	39·2	4	31·70	2	88·33	Sm.	
						38·9	4	31·89	2	·38	Sm.	
						39·2	4	32·80	2	89·19	H.	
4690		[229]	6½, 7	43·1	41 44	331·9	4			85·41	Sm.	Very unsteady.
						329·9	4	·80	est.	·41	Sm.	Definition perfect.
						327·0	4			·44	Sm.	Definition good.
4714		1486	7½, 8½	47·9	52 45	102·5	4	24·9	1	85·41	Sm.	
						102·5	4	28·08	1	·41	Sm.	
4839		[232]	7, 7½	11 8·4	38 13	228·0	4			85·41	Sm.	
						242·0	2			·41	Sm.	
						222·4	4			·44	Sm.	Definition good.
4860	ξ Ursæ Majoris	1523	4, 5	11·8	32 12	250·6	4	1·85	2	84·38	S.	
						250·5	4	2·01	2	·38	S.	
						244·7	4	1·93	2	85·32	S.	
						245·0	2	1·71	2	·35	Sm.	
						238·7	3	1·54	1	86·26	Sm.	
						239·2	4	1·64	1	86·40	Sm.	
						236·9	3	1·59	1	·42	Sm.	Very good definition.
						232·0	2	1·38	1	87·35	Sm.	Very bad definition.

						233·5	4	2·02	1	·37	Sm.	
						227·0	4	1·30	2	88·32	Sm.	
						226·2	4	1·32	2	·32	Sm.	
						227·2	4	1·34	2	·33	Sm.	
						217·1	4	2·40	2	89·12	H.	Hazy.
						215·5	1	1·50	1	·17	H.	Cloudy; hurried observation.
						217·9	4	2·10	2	·18	H.	
						216·5	4	1·70	2	·23	H.	
4896	ι Leonis	1536	4, 7	17·6	11 11	61·8	4	3·12	2	84·40	S.	
						63·4	4	2·94	2	·40	S.	
4976		1553	7½, 7½	30·0	56 48	167·7	4	5·67	1	85·41	Sm.	
						166·0	4	5·07	2	88·33	Sm.	
						164·7	4	5·22	2	·34	Sm.	
						166·8	4	4·73	2	·38	Sm.	
5126		[243]	7½, 8½	53·6	54 5	11·0	4			85·41	Sm.	
						10·5	4			88·33	Sm.	
						11·2	4			·34	Sm.	
						11·6	5			·38	Sm.	
5149		1593	8½, 8½	57·4	− 1 47	21·5	5	1·00	est.	84·40	S.	
						24·5	4	1·26	2	·40	S.	
						25·5	1			85·41	Sm.	Too low for accuracy.
5188	59 Virginis, β AB	1604	6½, 9, 8	12 3·2	−11 11	90·4	4			85·41	Sm.	
						92·3	3	11·10	1	84·33	Sm.	
						90·5	4	11·05	1	·34	Sm.	
						89·6	4	10·97	1	·38	Sm.	
	AC					93·4	4			85·41	Sm.	
						92·0	3	37·10	1	88·33	Sm.	
						90·5	4	37·80	1	·34	Sm.	
						89·6	4	37·79	1	·38	Sm.	
5196		1606	6½, 7	4·7	40 34	339·7	4	1·60	1	84·40	S.	
						339·2	4	1·35	2	·40	S.	
5193	Comæ 68 (B)	1639	6½, 8	18·4	26 15					84·40	S.	Round.
										88·34	Sm.	Round.

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
5305		1643	8, 8½	12 21·2	27 42	47·1	6	1·55	2	88·43	S.	
						45·4	4			·47	Sm.	
						48·7	5			·50	S.	
5307		1644	7½, 9	21·3	8 3	245·7	4			85·41	Sm.	
						247·4	4	13·77	2	88·34	Sm.	
						246·9	4	13·72	1	·39	Sm.	
5350		1661	8½, 8½	29·9	12 4	232·9	4			85·41	Sm.	Too faint for distance.
						236·1	4	2·75	2	88·34	Sm.	
5377	γ Virginis	1670	3, 3	35·6	− 0 47	157·4	3	5·42	2	84·40	S.	
						156·7	4	5·63	2	·40	S.	
5430	35 Comæ AB	1687	5, 8, 9	47·4	21 53	58·5	3	1·10	1	86·41	Sm.	Indistinct.
						68·3	1			·42	Sm.	Very uncertain.
	AC					125·5	3	23·10	1	86·41	Sm.	
						126·3	2	22·35	1	·42	Sm.	$\frac{AB}{2}$, C.
5452		[257]	7½, 8	51·3	46 15	353·0	2	12·80	3	84·48	Sm.	
						352·7	4	13·14	2	·55	S.	
5614		1747	8, 9½	13 22·7	48 23	346·7	4	13·47	1	86·42	Sm.	Very faint.
						346·5	1			·74	Sm.	Very faint.
5639	P.XIII. 127 Virginis	1757	8, 9	28·2	0 18	73·2	4			84·40	S.	
						70·3	4	2·46	2	·40	S.	
5691		1772	6½, 9	34·9	20 33	145·0	2	4·66	1	84·49	Sm.	Very faint.
						143·7	4	4·44	1	·55	S.	
						145·9	5			·59	S.	
5707		1776	8, 8	36·8	46 50	201·0	2	7·24	1	84·49	Sm.	
						199·7	4	7·20	2	·50	S.	
						199·9	4	7·85	2	·54	S.	
						200·4	1			·54	Sm.	
5754		1785	7, 7½	43·6	27 35	221·8	4	2·09	1	82·44	S. and Sm.	
						220·3	4	2·20	2	·45	S.	

						221·9	4	2·36	2	·45	S.	
						226·1	4	1·74	2	84·60	S.	
						227·1	4	1·83	2	·67	S.	
						227·5	2	1·73	2	85·35	Sm.	
						228·3	4	1·72	1	·51	Sm.	
						231·5	2	1·61	1	86·4	Sm.	
						231·3	3	1·31	1	·42	Sm.	
						232·2	2	1·08	1	87·35	Sm.	
						233·4	4			·55	Sm.	Very bad definition.
						236·0	4	1·19	2	88·32	Sm.	
						235·5	4	1·17	2	·33	Sm.	
						238·0	4	1·00	2	·33	Sm.	
						234·4	4	1·60	2	89·18	H.	Bad definition.
						231·2	4	1·60	2	·23	H.	
						240·4	4	1·60	2	·42	H.	
5797		[272]	7, 10	49·0	30 29	19·0	2			84·54	S.	Bad night.
						21·5	3			·55	S.	Very faint.
						22·2	2			85·42	Sm.	Uncertain.
5880		1808	8, 9	14 4·7	27 10	73·8	3			84·56	S. and Sm.	
						74·1	4	2·75	1	·56	S.	
5894	AB	1812	7½, 8, 9½	7·1	29 16	339·8	3			84·55	Sm.	Very difficult.
										·56	S.	Failed.
	AC					110·5	3	13·6	1	84·55	Sm.	Very faint.
						108·2	4	14·54	2	·56	S.	
						108·0	4			85·41	Sm.	
						110·4	3	12·9	2	88·39	Sm.	
5898		[279]	6½, 9	8·0	12 33	257·9	4	2·00	est.	85·41	Sm.	
						253·5	4			·42	Sm.	Very faint.
5907		1819	8, 8	9·3	3 41	15·2	4			85·48	Sm.	
						18·7	4			·56	S.	
						12·5	2	1·5	1	86·40	Sm.	
						7·8	4	1·00	est.	·42	Sm.	Good definition.
						14·0	2	1·59	1	·49	Sm.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	°	°		"				
5907	(*continued.*)					12·4	4			86·50	Sm.	
						14·5	4			·54	Sm.	Definition bad.
						8·0	4			88·39	Sm.	Nearly 1 sec. dist.
						0·9	4	1·00	2	89·23	H.	
						2·0	2	1·10	1	·42	H.	
5913		1820	$8\frac{1}{2}$, $8\frac{1}{2}$	14 9·1	55 53	68·7	5	2·76	2	84·55	S. and Sm.	
						69·3	4	2·67	2	·56	S.	
5194		1847	$8\frac{1}{2}$, $9\frac{1}{2}$	22·2	− 9 40	260·4	4	22·55	1	85·42	Sm.	
5954		1834	7, 7	15·9	49 3	114·6	4			84·70	S.	
						110·0	4			·71	S.	Doubtful ; very close.
6088		1871	7, 7	37·5	51 55	291·2	4	1·65	2	84·55	S.	
						290·8	4	1·97	2	·56	S.	
6099		1876	8, $8\frac{1}{2}$	40·0	− 6 53	89·5	3	1·50	est.	86·42	Sm.	Very hazy.
6115		[285]	7, $7\frac{1}{2}$	41·0	42 53	235·0	1	0·30	est.	85·42	Sm.	Uncertain.
										·44	Sm.	Round.
6146	ξ Boötis	1888	$4\frac{1}{2}$, $6\frac{1}{2}$	45·8	19 36	266·2	4	4·10	2	84·60	S.	
						266·3	4	4·11	2	·67	S.	
						264·6	4	3·40	2	85·56	S.	
						260·0	3	2·89	1	86·54	Sm.	
						257·7	4			87·55	Sm.	Bad definition.
						247·5	4	3·10	2	89·23	H. and S.	
						250·4	4	3·00	1	·42	H.	
						250·4	4	3·20	2	·43	H.	
6159		[287]	$7\frac{1}{2}$, $7\frac{1}{2}$	47·1	45 25	315·2	4	1·00	1	84·56	S. and Sm.	
						317·0	4	·80	est.	85·42	Sm.	
6161		[288]	$6\frac{1}{2}$, $7\frac{1}{2}$	47·8	16 11	196·8	3	1·39	1	86·42	Sm.	
6181		1893	$8\frac{1}{2}$, 10	50·2	29 58	246·6	4	20·43	[illegible]	84·55	S.	
						246·5	4	18·70	1	85·42	Sm.	
6237	44 Boötis	1909	5, 6	59·9	48 7	242·0	4	5·19	2	85·44	Sm.	

						240·3	3	4·73	1	86·42	Sm.	
						242·0	3	4·48	1	·69	Sm.	
6310		1926	6, 8½	15 10·4	38 45	265·0	4	1·00	est.	85·44	Sm.	Too faint for distance.
6311		[295]	7½, 9	10·4	37 16	129·0	1			85·44	Sm.	A guess ; beyond our power.
6305		1925	7½, 9½	10·5	− 7 50	9·0	2	5·0	est.	85·44	Sm.	Too faint for distance.
6327	5 Serpentis	1930	5, 10	13·1	2 13	37·5	2			85·44	Sm.	Almost invisible.
6331	Coronæ 1 B	1932	5, 6	13·2	27 16	308·9	4			85·54	Sm.	
						313·7	3	1·41	1	·74	S. and Sm.	Bad definition.
						314·0	4			·75	Sm.	
6348		3093	8, 9¼	16·4	− 1 6	142·0	4	28·20	1	85·44	Sm.	
						141·2	1	28·60	2	·44	S.	
6362	η Coronæ	1937	5½, 5½	18·2	30 43	173·3	5			84·60	S.	
						171·1	4			·67	S.	
						172·9	4			·71	S.	
						173·7	4			85·48	Sm.	Just divided.
						170·6	4			·50	Sm.	Divided.
						167·2	4			·51	Sm.	Definition **very** good.
						171·7	4	·70	1	·56	S.	
						170·4	1			·56	Sm.	
						184·0	2			86·49	Sm.	
						182·4	4			·50	Sm.	
						177·5	4	·80	est.	·54	Sm.	Unsteady, but well divided.
						182·0	2			89·42	H.	Elongated only.
6371	μ^2 Boötis	1938	6½, 7½	20·0	37 46	118·4	4			84·60	S.	
						119·3	4			·67	S.	
						125·5	4			·71	S.	
						116·3	4			·71	S.	
						106·4	4	1·00	est.	85·48	Sm.	Well divided.
						105·6	4			·48	Sm.	
						105·5	3			·51	Sm.	
						107·0	2			86·49	Sm.	
						106·4	4			·50	Sm.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
6371	μ^2 Boötis (*continued.*)					99·0	4			87·55	Sm.	
						96·2	4	1·00	2	89·418	H.	
						108·0	2			·428	H.	Bad definition; unreliable.
6388		[296]	7, 8½	15 22·2	44 26	309·7	4			85·51	Sm.	
						310·0	4			·74	Sm.	Definition very bad.
						310·4	4			·75	Sm.	
6426	δ Serpentis	1954	3, 4	29·1	10 56	190·1	3	4·14	1	85·51	Sm.	
						188·3	4			·74	Sm.	Hazy.
						187·6	4	3·60	1	·75	Sm.	
6430		1956	8, 9½	29·0	42 12	39·2	4			85·44	Sm.	Too faint for distance.
						39·4	4	2·00	est.	·45	Sm.	
6440		1961	8½, 9	30·3	43 57	49·6	4	20·40	1	85·44	Sm.	Very faint.
						48·6	4			·45	Sm.	
6469	γ Cor. Bor.	1967	4, 7	37·7	26 40					85·48	Sm.	Round.
										87·55	Sm.	Round.
										89·42	H.	If anything, 109°.
6534		1984	6¼, 8¼	48·1	53 16	272·8	4	6·11	2	85·44	Sm.	
						277·2	4	6·55	1	·45	Sm.	
6566		1993	8¼, 8¼	54·4	17 43	39·2	4	29·30	2	85·44	Sm.	
						39·3	4	29·00	1	·45	Sm.	
6575		[303]	7½, 7½	55·2	13 27	136·0	4			85·44	Sm.	
										·45	Sm.	Failed.
										·48	Sm.	Failed.
						147·0	1			86·72	Sm.	Very doubtful.
6582	ξ Scorpii AB	1998	4½, 5, 7½	57·7	− 11 2	195·0	2			85·48	Sm.	Bad definition.
						198·0	2	1·54	1	86·49	Sm.	
						199·3	3			·50	Sm.	
						200·2	4	1·20	2	89·41	H.	
						194·8	4	1·20	2	·45	H.	

		AC					69·1	4			85·48	Sm.	
							65·5	1			·51	Sm.	AB too blurred to give good readings.
							65·5	4	5·91	1	86·49	Sm.	
							71·5	3	5·57	1	·50	Sm.	
							72·0	2	4·24	1	·54	Sm.	Hazy.
							70·5	4	5·70	2	89·42	H.	Careful readings.
							68·8	4	5·8	2	·46	H.	
6521	ν Scorpii	AB		4, 7, 7, 8	16 5·0	− 19 9	357·3	1			86·42	Sm.	
		CD					218·3	1	1·00	est.	86·42	Sm.	
		A/B C/D					338·3	1			86·42	Sm.	
6654	σ Coronæ	AB	2032	5, 6, 10, 12½	10·2	34 9	206·3	3	3·40	1	86·42	Sm.	
							206·5	2	3·50	1	·69	Sm.	
6727	λ Ophiuchi		2055	4, 6	24·9	2 14	42·6	4			84·60	S.	
							41·6	4			·60	S.	
							44·4	4	2·27	2	·67	S.	
							39·6	4			85·48	Sm.	Bad definition.
							39·0	4			·51	Sm.	
							40·4	4	1·82	1	·56	S.	
							36·3	4	1·54	1	86·49	Sm.	
							41·3	4			·50	Sm.	
							42·1	3	1·00	1	·54	Sm.	
							40·1	4			87·55	Sm.	Bad definition.
							47·4	4	1·30	2	89·42	H.	Readings accordant.
							44·0	4	1·20	2	·45	H.	
							47·0	4	1·10	2	·46	H.	
6799	ζ Herculis		2084	3, 6½	36·8	31 49	99·4	4	1·97	1	84·67	S.	
							92·8	4	1·93	2	·67	S.	
							96·4	5			·71	S.	
							101·3	4			·71	St.	
							90·5	4			·71	S.	
							88·5	1			·74	Sm.	
							89·6	4	1·97	2	85·64	S.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
6799	ζ Herculis (*continued.*)					91·4	5	1·96	2	85·74	S.	
						84·4	4			86·49	Sm.	
						85·5	1			·54	Sm.	Bad definition.
						85·2	4			·71	Sm.	
						77·0	4	1·00	2	89·45	H.	
6847	167 B Herculis	2107	6½, 8	16 47·1	28 52					84·67	S.	Round.
										85·51	Sm.	Round? about 80.
										86·54	Sm.	Round? about 78.
						243·0	1			89·45	H.	? if anything.
6888	P XVI. 270	2144	6, 7½	56·2	8 37	156·7	4	1·00	est.	85·51	Sm.	
						156·7	4			·74	Sm.	
6910	210 B Herculis	2120	6½, 9	17 0·0	28 15	250·7	4	5·17	1	85·51	Sm.	
						250·2	4			·71	Sm.	
						253·3	4	4·22	2	·74	S.	
6935	μ Draconis	2130	5, 5	2·8	54 37	164·5	4	3·50	1	85·51	Sm.	
						162·7	2	2·42	1	·71	Sm.	
						164·9	4	2·96	2	·74	S.	
7142	μ Herculis AB	2220	4, 9½, 10½	41·8	27 48	245·0	1			85·51	Sm.	
						245·5	1			·74	Sm.	B barely visible.
	BC					147·0	1			85·74	Sm.	A guess.
										·74	Sm.	Failed.
										·75	Sm.	Impossible.
7245	τ Ophiuchi	2262	5, 5½	56·5	− 8 10	255·0	4			86·69	Sm.	Very unsteady.
						252·5	3	1·49	1	·74	Sm.	
						254·6	4	1·50	2	89·51	Sm.	
						252·5	4	1·30	2	·54	Sm.	
7273	70 Ophiuchi	2272	4, 6	59·4	2 33	33·4	4	2·66	2	84·67	S.	
						36·2	4			·71	S.	
						35·0	4	2·45	2	·71	S.	

							24·6	4			85·48	Sm.	
							23·4	4			·51	Sm.	
							26·5	4	1·65	1	·51	Sm.	Good definition.
							26·0	4	2·30	2	·74	S.	
							18·0	2	2·07	1	86·54	Sm.	Bad definition.
							15·5	2	1·96	1	·69	Sm.	
							16·2	3			·69	Sm.	Unsteady.
							13·7	4			·74	Sm.	Good.
							359·6	2			87·55	Sm.	
							347·0	4	1·50	2	89·45	H.	Careful readings, perfectly accordant.
							342·9	4	1·70	2	·51	H.	
7479				7, 7	18 30·5	16 54	199·6	4			84·76	Sm.	
							199·3	4			·78	Sm.	
							200·2	4			·79	Sm.	Very bad definition.
7505			2356	8, 9	33·7	28 35	62·6	4			84·76	Sm.	Bad definition.
							61·5	4	1·00	est.	·80	S. and Sm.	
7564	ε Lyræ	AB	2382	4½, 6½, 5, 5	40·4	39 32	17·5	2	2·81	1	85·51	Sm.	
							15·8	4	3·71	2	·74	S.	
							16·5	3			·74	Sm.	
		AC					173·0	1			85·51	Sm.	
							173·0	2			·74	S.	
		CD					136·0	2	2·22	1	85·51	Sm.	
							136·1	4	2·31	2	·74	S.	
7593			2396	7½, 11	42·8	10 38	319·0	3	22·33	3	85·74	S.	
							318·2	2			·75	Sm.	Too faint for distance.
							319·0	3			·75	Sm.	
7625			2409	8, 9½	46·2	13 22	32·8	5			83·73	S.	Unsteady.
							34·6	3	1·20	est.	84·74	S. and Sm.	Very difficult.
							31·0	4			·76	Sm.	
							38·5	2			·76	Sm.	A mere guess.
							32·2	4			·78	Sm.	Divided.
							33·6	3			·80	S.	Readings very wild.
7752			2454	8, 9	19 1·5	30 15	234·2	2			85·75	S.	
							232·8	3			·75	Sm.	
							237·2	3			·75	Sm.	Uncertain.

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7753		2455	7, 8½	h m 19 1·7	° ′ 21 59	96°·7	4	″ 3·02	2	83·56	S.	
						96·9	4	3·34	2	·65	S.	
						97·3	4	3·88	2	·66	S.	
						89·9	4	3·00	est.	86·69	Sm.	B very faint.
						94·1	2	3·68	1	·71	Sm.	Satisfactory.
						91·8	4	3·10	1	·72	Sm.	Satisfactory.
						93·6	3	2·61	1	·74	Sm.	Steady.
						91·0	2	3·51	1	89·51	H.	
						90·5	2	3·51	1	·54	H.	
8079	ξ Vulpeculæ	2556	7½, 8	34·3	21 59	172·6	3	·50	est.	85·75	Sm.	
						162·0	1			·75	Sm.	Very doubtful.
						161·4	1			·78	Sm.	
8153	δ Cygni	2579	3, 8	41·2	44 50	319·9	3	1·39	1	85·74	S. and Sm.	
										·75	Sm.	Failed.
										·78	S. and Sm.	Failed.
8159	17 Cygni χ	2580	5, 8	41·8	33 27	71·2	4	24·75	1	85·75	Sm.	
						71·2	3	22·89	1	·75	Sm.	
						72·1	4	23·24	1	·78	Sm.	
8219	192 Aquilæ	2596	7, 8½	48·5	14 59	336·0	4			84·76	Sm.	
						337·6	4			·78	Sm.	
8411		[400]	7, 8	20 6·2	43 37	176·0	1	1·00	est.	85·75	Sm.	Mags. 7, 10? doubtful.
										·75	Sm.	Failed.
						168·4	1			·78	Sm.	Very doubtful.
8516		[406]	7, 8	15·9	44 59	276·0	1			85·75	Sm.	Very doubtful.
						186·0	est.			·78	Sm.	Very doubtful.
						284·6	3			·82	Sm.	Very doubtful.
8773	λ Cygni	[413]	5, 6½	42·5	36 3	71·2	3	·80	est.	85·75	Sm.	
						71·6	4			·75	Sm.	
						70·4	4			·78	Sm.	Very bad definition.
8784	4 Aquarii	2729	6, 7	20 45·0	− 6 5	182·1	4			83·84	S.	
						153·0	1			84·74	Sm.	Not divided; unsteady.
						177·0	3			·76	Sm.	

						170·0	2			·76	S.	
						171·0	4	1·00	est.	·76	Sm.	
						170·5	3			·78	Sm.	Shaky.
						160·3	4			·79	S.	
						165·6	4			·84	S.	
						156·1	4			85·64	S.	
						162·5	1			86·69	Sm.	Very doubtful.
										·74	Sm.	Cannot divide.
						155·5	1			89·51	S. and H.	Very doubtful.
										·77	H.	Cannot divide.
8884	83 B Cephei	2751	6, 7	58·7	56 11	173·2	4	1·74	2	84·84	S.	
						171·0	4			·86	Sm.	
						171·7	4	1·68	2	·92	S.	
8898	61 Cygni	2758	5½, 6	21 1·2	38 7	119·0	2	20·18	3	84·06	S.	
						120·0	3	20·00	1	·74	Sm.	
						120·0	4			·74	Sm.	
						120·0	3	19·73	1	·74	S.	Distance through cloud.
						120·0	2	19·82	3	85·74	S.	
						120·9	1	19·40	1	86·69	Sm.	Careful readings.
						120·7	4	18·47	2	87·82	Sm.	Bad definition.
						120·2	4	18·90	2	·87	Sm.	
								18·725	5	87·90	Sm.	Very careful readings.
						121·4	4	18·70	2	88·79	S.	
						121·2	4	18·67	2	·90	H.	
						120·0	4	17·53	2	89·52	H.	
						121·2	4	17·30	2	·77	H.	
						121·3	2	17·18	1	·83	H.	
		[527]	7, 8	2·0	4 40	86·8	4	0·50	est.	84·84	S.	
						85·1	4			·86	S.	
						82·8	3			·92	S.	
										85·78	Sm.	Round.
8932			8, 8	5·7	−15 31	149·5	4			84·84	S.	
						140·0	3			85·75	Sm.	Definition very bad.
						143·0	est.			·78	Sm.	
8959	δ Equulei AC	2777	4, 10, 10	8·6	9 31	20·4	3	37·90	1	85·75	Sm.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+	Observer.	Remarks.
				h m	° ′	°		″				
8959	δ Equulei AC					20·5	2			·75	Sm.	
	(*continued.*)					20·5	1	37·70	1	·82	Sm.	
9158	AB	[445]	8, 8½, 10	21 33·7	20 10	112·6	3			84·84	S.	
						106·3	3			·86	S.	
						103·5	2	0·70	est.	·89	S.	
	AC					280·7	1	7·00	est.	84·84	S.	
						279·1	4			·86	S.	
						279·1	2			·89	S.	Very faint.
9260		2833	7, 10	46·0	8 30	161·2	4	9·50	2	84·84	S.	
						160·9	4			·86	Sm.	
						161·7	4			·89	S.	
9308		2846	8, 10	50·1	45 13	91·0	3	3·06	1	84·84	S.	± 180°.
						90·2	4	3·56	2	·89	S.	
						269·2	2			·92	S. and Sm.	
						270·2	1			·92	H.	
9325		2847	8, 8	51·9	− 4 4	129·1	2	1·00	est.	84·89	S.	Doubtful.
						134·5	4			·93	S.	Estimated only.
						118·0	2			85·75	Sm.	Bad definition.
						118·1	2			·78	Sm.	Estimated only.
9516		2895	8½, 10	22 15·1	24 21	29·4	4			85·75	Sm.	Too faint for distance.
						30·6	4	6·41	1	·78	Sm.	
						31·1	2	6·15	1	·82	Sm.	
9930	π Cephei	[489]	5, 7½	23 4·0	74 44	215·7	4			86·09	Sm.	
										89·77	H.	Cannot divide.
10020	P. XXIII. 69 Aquarii	3008	7, 8	17·5	− 9 7	252·1	3			85·78	Sm.	Barely visible.
						251·7	4	3·46	1	·82	Sm.	
10304	B. A. C. 8372	3062	7, 8	59·9	57 46	312·2	2	1·08	1	84·03	S.	
						311·2	4	1·45	1	·92	S.	
						315·8	3	1·26	1	86·09	S.	
						318·6	4	1·58	2	·24	S.	
						311·2	4			·26	Sm.	
						320·5	4	1·38	2	89·94	H.	Doubtful readings.

Observations of the Spectra of Sun-spots in the region B—D, made at the Stonyhurst College Observatory. By Rev. A. L. Cortie, S.J.

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Contents.

PAGE

Introduction 30

Section 1. Table I. List of lines between B and D widened in the spectra of Sun-spots 1882–89 31

Section 2. Behaviour of metallic lines in the spectra of Sun-spots . 42

Table II. Widening of iron-lines in the spectra of Sun-spots between B and D. Percentage Curve illustrating the same.

Table III. The "basic" lines in Sun-spot spectra between B and D.

Section 3. Lines of unknown origin in the spectra of Sun-spots between B and D 50

Table IV. List of faint lines always much widened in Sun-spots.

Table V. Percentage of lines of unknown substances more widened in the spectra of Sun-spots between B and D.

Section 4. The C and D_3 lines in the spectra of Sun-spots 53

Section 5. Various observations on the spectra of Sun-spots between B and D 55

Introduction.

The present pages contain a discussion of the observations of ninety Sun-spots, made in the years 1882–89 at the Stonyhurst Observatory, in the region of the spectrum contained between the lines B and D. The observations are intended to supplement those made at South Kensington and at Greenwich between D and F. They are, however, more comparable with the latter series, as, when time and opportunity permitted, the spectrum of each spot was studied in detail, and not merely the most widened lines recorded. On some few occasions it has been possible, in this manner, to study every line affected in the spots between B and D; but generally, after a rapid scrutiny of this region of the spectrum, some special portion was selected for closer study. Accordingly, the average widening of the lines has been deduced in each case from varying numbers of observations. The instrument employed was the Browning automatic spectroscope, attached to the 8-inch equatoreal, and a dispersion of twelve prisms of 60° was nearly always used. Some few observations were taken in the years 1882–83, and the results deduced have already appeared in a paper by the late Father Perry (*Monthly Notices, R.A.S.*, Vol. xliv. No. 5). Since 1884 much greater attention has been paid to this class of solar observations. Sun-spots were numerous both in the years 1884, 1885, and in the early part of 1886. In the autumn of 1886 the Sun-spot curve had dropped almost to a minimum (Stonyhurst College Observatory Report, 1887, page 42). In the present discussion, therefore, the observations of the spectra of Sun-spots have been separated into two series—the first from the beginning of 1884, to October, 1886; and the second from October, 1886, to the end of June, 1889; and they are designated "disturbed" and "quiet" period respectively.

In the construction of Table I. the first column gives the wave-length of the line; the second column, its origin; the third column, the number of observations taken of the line in the disturbed period; the fourth column, the average widening deduced, reckoned in tenths of the normal breadth of the line; the fifth and sixth columns give the number of times the line has been among the more widened or most widened lines respectively. These last four columns are repeated for the quiet period, so that the results may be compared. A column for Remarks is appended. When a line has been widened

between 0·5 and 1·0 of its normal breadth it is called a "more" widened line; when 1·0 or above, it is called a "most" widened line. With these two values as standards it has been found more easy to compare the observations with one another. The authority for wave-lengths given has been as far as possible the catalogues published in the Reports of the British Association for the years 1878, 1884, and 1885, and the maps of Ångström. When a wave-length has been taken from any other source it has been indicated. In the remarks, A., B., F., S., K., L. and D., refer to the numbers and maps of Ångström, Burton, Fievez, Piazzi Smyth, Kirchhoff, Liveing and Dewar. Whenever a line is marked with an asterisk, it denotes that the line occurs in Young's list of chromospheric lines. By an obvious analogy the musical signs ♯ and ♭ have been used to denote displacements of the lines towards the violet and red ends of the spectrum.

Section I.

Table I.

Lines between B and D widened in the Spectra of Sun-spots. 1882–89.

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
6867·1	B.	9	0·3	2	1	...	...	...	...	1883. Twice darkened, remarkably in nucleus of spot of Oct. 22 on P limb.
56·3		13	0·4	6	0					
43·8		8	0·5	6	0	...	...	...	...	1883. Very dark three times.
28·0		1	0·4							
19·0		2	0·5	2	0					
6788·7		4	0·4	3	0					
61·2		3	0·3	1	0					
...		1	0·5	...	...	...	...	...	...	Faint line.
26·5	Ca.	12	0·4	5	0	2	0·5	1	0	
21·2 (F.)		2	0·5	2	0	1	0·5	1	0	Darkened once.
17·16	Ca.	11	0·3	3	0	2	0·4	1	0	1883. Six observations, mean 0·2. Three times darkened.—May 27, 1884, very dark. ♯ March 28, 1883.
03·0		11	0·3	3	0	2	0·4	1	0	Darkened once.
01·0		12	0·2	1	0	2	0·2	0	0	„ twice.

Table I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
*6677·6	Fe. ?	25	0·3	2	0	3	0·5	2	0	1883. Nine observations, mean 0·3. Three times very dark. Frequently seen bright in the chromosphere.—June 6, 1885, less dark over a spot on the limb.
63·1	Fe.	25	0·2	2	0	2	0·4	1	0	1883. Nine observations, mean 0·2. Darkened four times.
...		1	0·8	...	...	...	...	...	...	Faint line.
43·1		24	0·2	1	0	3	0·4	1	0	1883. Nine times, mean 0·2. Darkened four times.
38·8 (F.)		8	0·5	6	0	3	0·7	3	0	Line not in Angström.
33·3		24	0·2	1	0	3	0·4	1	0	1883. Nine times, mean 0·2. Darkened three times.
...		6	0·6	4	0	1	0·8	1	0	Line not in Ångström. Perhaps S. 27·0.
...		1	0·6	...	...	...	...	...	...	„ „ „ F. 25·3.
...		6	0·6	5	1	1	0·6	1	0	„ „ „ S. 24·8.
09·2 (F.)		1	0·8	1	0	...	...	...	...	„ „
03·3 (F.)		6	0·2	1	0	3	0·6	2	0	„ „
04·1	Fe.	18	0·4	5	0	3	0·8	3	1	1883. Once 0·5
6597·6		15	0·4	10	0	3	0·9	3	1	
93·3	Fe.	21	0·2	3	0	1	0·3	...	...	1883. Twelve times, mean 0·2. Darkened five times.
92·6		20	0·2	4	0	5	0·8	5	1	June 27, 1889. 1·5.
85·9		18	0·4	11	0	4	0·6	2	1	1883. Five times, mean 0·3.
80·6		17	0·5	13	0	4	0·7	2	1	1883. Three times, mean 0·3.
74·0	Fe.	27	0·3	8	0	5	0·6	4	1	1883. Ten times, mean 0·3. Darkened three times.
71·4		18	1·0	17	8	7	0·9	7	2	1882. Four times, each 1·0. A faint line 1*a* K.'s scale. Always very much widened, both in max. and min. spots.—April 30, 1886. Widened 3·0.
67·9		19	0·3	4	0	5	0·5	3	1	1882. Four times, each 0·5.
* 62·10	C.H.	For special discussion vid. infra, p. 53.								
58·42		1	0·4							
50·07		5	0·6	4	1	1	0·6	1	0	Identification with A. doubtful.
45·40	Fe.	2	0·4	...	...	1	0·3	0	0	
43·23		13	0·3	4	0	...	...	...	...	1883. Five times, mean 0·1. Darkened four times.
31·74		11	0·3	2	0	1	0·5	1	0	Identification with A. doubtful.
17·59		3	0·7	3	1					

TABLE I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
...		1	0·4	...	...	...	...	...	...	Faint line.
*6515·80	...	19	0·4	5	0	1	0·3	0	0	1883. Six times, mean 0·2.
11·64	...	4	0·7	4	0					
...		1	0·6	...	...	...	...	...	...	Faint line.
6498·25	Ca.	14	0·5	8	0	3	0·6	3	0	
*96·31	Ba.	11	0·3	1	0					
95·12	Fe.	11	0·2	0	0	...	...	...	...	1883. With 94·18. Eleven times, mean 0·4.
94·18	Fe.	19	0·4	9	1	3	1·3	3	2	May 20, 1884, 1·0. June spot, 1889, 1·0 and 2·0. Very dark, July 1, 1886.
92·41	Ca.	15	0·5	7	0	3	2·0	3	3	Very dark, July 1, 1886. June spot, 1889, 1·5 and 3·0.
90·07	Fe.	16	0·3	2	0	3	0·5	2	0	Darkened once.
85·0	...	2	0·4	0	0					
82·79	...	18	0·3	4	0	1	0·8	1	0	1883. Six times, mean 0·3.
81·18	...	8	0·3	3	0	1	0·3	0	0	
79·01	...	9	0·5	7	1	1	0·3	0	0	May 25, 1884, 1·0.
...		2	0·9	2	1	...	...	...	...	Faint line.
74·85	...	19	0·3	1	0	3	0·5	1	0	1883. Six times, mean 0·3.
71·85	...	11	0·3	1	0	4	0·4	1	0	Darkened once. ♯ October 2, 1886.
70·75	...	10	0·2	0	0	4	0·5	1	1	May 7, 1889, 1·0. Darkened once. ♯ October 2, 1886.
68·78	Ca.	11	0·4	5	0	4	0·6	2	1	Darkened once. September 27, 1888, 1·0. ♯ October 2, 1886.
...		1	0·8	...	...	...	...	...	...	Faint line.
67·14	...	4	0·3	0	0	2	0·3	0	0	♯ October 2, 1886.
...		1	0·6	...	...	1	0·5	...	...	Faint line.
63·74	...	6	0·6	5	0	1	0·8			
...		4	1·2	4	2	2	0·9	2	1	Faint line. July 7, 1886, 2·0.
*61·98	Ca. + Fe.	27	0·4	6	0	12	0·8	8	4	1883. Once, 0·3. May 7, 1889, 1·0. June spot, 1·0 and 2·0. Fe. less refrangible L. and D. F. resolves. ♯ May 26, 1886.
...		1	0·6	...	...	...	...	...	...	Faint line.
...		5	0·7	5	1	5	0·4	3	0	Perhaps F. 58·0.
...		4	0·	...	...	...	...	...	...	Faint line, seen in June and July, 1886, and not widened.
*54·09	...	23	0·4	11	1	6	0·6	5	0	July 7, 1886. 1·0, and very dark. Darkened three times. A double.
...		2	0·8	...	...	...	...	...	...	Darkened once. Faint solar line.

Table I.—(*continued*.)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
...		6	1·2	6	6	...	...	...	...	July 7, 1886. 2·0. Faint line.
...		1	0·5	...	...	...	...	...	...	Faint line.
6449·29	Ca. + Ba.	26	0·4	3	0	12	0·8	8	4	May 7, 1889. 1·0. June spot, 1889. 1·0 and 2·0. Until then limits 0·2 to 0·6. Ca. more refrangible L. and D. F. resolves.
*38·35	Ca. + Cd.	28	0·4	4	0	12	0·7	8	3	June spot, 1889. 1·0 and 2·0. Until then limits 0·1 to 0·7. Cd. more refrangible L. and D. F. does not resolve.
31·73	...	10	0·4	6	0	6	0·2	1	0	Unaffected in spot, May 25, 1884; May 7, and June 20, 1889.
*30·12	Fe.	25	0·3	1	0	6	0·6	5	1	May 7, 1889. 1·0.
...		2	1·0							
...		2	0·9	...	...	1	0·8	...	...	Faint lines.
20·63	Fe.	26	0·2	4	0	6	0·5	3	0	
19·17	...	25	0·2	1	0	6	0·5	3	0	
*15·90	...	15	0·3	4	0	6	0·3	2	0	Darkened three times. Less dark over the nucleus of spot, July 4 and 7, 1886. Obliterated over spots, May 26, 1886, and June 20, 1889. Two faint lines.
14·10	...	15	0·3	4	0	6	0·3	2	0	
...		1	...	...	...	...	...	...	...	Spot line; very wide, July 4; very dark, July 7, 1886.
10·62	Fe.	26	0·3	1	0	8	0·4	4	0	Very regular, limits 0·2 to 0·5. Increasing in 1888–89.
*07·38	Sr. + Fe.	26	0·3	1	0	8	0·4	4	0	Very regular, limits 0·1 to 0·5. Increasing in 1888–89. Fe. more refrangible L. and D. F. resolves.
...		5	0·9	5	3	1	0·8	1	0	Two faint lines, seen in 1886 in spots, and May 6, 1889. Young, in his diagram (The Sun, p. 129), draws a bright band about this position.
...		6	0·9	6	2	1	0·8	1	0	
*6399·28	Fe.	29	0·3	1	0	9	0·5	4	0	Very steady. June spot, 1889, 0·8. 1883. Four times, mean 0·2. Darkened twice.
...		2	0·8	2	0	...	...	...	...	Two faint spot lines, seen in 1886.
...		3	0·8	3	0	...	...	...	...	
*92·87	Fe.	29	0·2	0	0	9	0·4	4	0	1883. Four times, mean 0·2. Darkened twice. Very steady.
...		1	0·6	1	0	4	2·0	4	4	Two faint lines, seem to be F. 84·5, 83·5. Position of a spot-band. Very much widened in June spot 1889, though no spot-band seen.
...		1	0·8	...	...	...	...	...	...	Spot-line, 90·5 F.
79·99	...	7	0·4	2	1	2	1·2	1	1	May 24, 1884, 1·0. June 20, 1889, 2·0. Unaffected, July 7, 1886.

TABLE I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks
6377·58	...	6	0·5	3	1	2	0·6	1	0	May 24, 1884, 1·0.
69·5 (F)	...	2	0·6	2	0	1	0·			
64·49	...	2	0·8	2	0	2	0·4	0	0	In A.'s catalogue, not in his map.
61·41	Zn.	5	0·5	5	0	2	0·4	0	0	Zn., on authority of British Association Catalogue, 1878. Lockyer (*Phil. Trans.* vol. clxiii. pt. 1) gives 771·7 K. as equivalent to *w. l.* 6362·5, and says: "This line was in the Sun in Kirchhoff's time, but has now (1873) dropped out."
57·92	Fe.	7	0·3	0	0	2	0·4	1	0	
54·28	Fe.	7	0·3	0	0	2	0·4	1	0	
...		...	...	...	...	1	1·0	...	...	Faint line.
*46·34	Ru. + Ir.	7	0·4	2	0	2	0·4	0	0	
43·40	Ba.	7	0·4	2	0	2	0·6	2	0	
38·21	...	7	0·3	1	0	4	0·3	3	0	
36·16	Fe.	7	0·3	1	0	4	0·5	3	0	Darkened once.
34·54	Fe.	7	0·2	0	0	4	0·5	3	0	" "
...		1	0·8	...	...	2	0·9	2	2	Three faint lines.
...		1	0·7	...	...	1	1·0	...	...	
...		...	...	...	...	2	0·	...	...	
21·81	Fe.	7	0·3	3	0	2	0·6	2	0	Darkened three times.
18·41	Fe.	6	0·2	0	0	2	0·3	0	0	" twice.
17·17	...	4	0·2	0	0	2	0·5	1	0	" once.
14·18	Fe.	7	0·4	1	1	2	0·6	1	0	" once. May 20, 1884, 1·0.
09·78	...	7	0·5	6	0	3	1·4	3	3	June 22, 1889, 3·0. A faint line in A.'s map. May 6, 1889, seen as a double or triple.
05·0	...	5	0·6	5	1	7	2·1	7	7	Wave-length doubtful. A double. F. has the lines. May 25, 1884, 1·0. June spot, 1889, four times, 3·0. Oct. 3, 1886, 0·9, and appearance of a band. Young, in his diagram (*loc. cit.*), has drawn a similar appearance.
01·88	...	8	0·2	1	1	2	0·4	1	0	Black and close double. 6301·88, 1·0 May 27, 1884, while 01·03 unaffected. Darkened once.
01·03	...	8	0·1	0	0					
00·5	Fe.	...	...	...	...	3	0·6	2	1	In A.'s map, not in his catalogue June 27, 1889, 1·0 and ♯.
6298·74	Fe.	7	0·3	1	0	3	0·6	2	1	June 27, 1889, 1·0 and ♯.
96·95	...	7	0·3	1	0	2	0·5	2	0	
...		2	0·1	0	0	1	0·4	0	0	Probably K. 801·5. Darkened once. A. on map has a line at 93·5.
94·27	...	3	0·3	...	...	...	...	...	...	A double.

Table I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
6291·78	...	7	0·3	1	0	2	0·7	2	0	
90·31	...	7	0·3	0	0	2	0·5	1	0	
86·69	...	2	0·7	2	0	2	0·3	0	0	
84·99	...	2	0·8	2	1	2	0·5	1	0	
81·81	...	3	0·5	3	0	2	0·4	1	0	June 20, 1889. Obliterated over the spot.
79·79	...	4	0·5	3	0	2	0·8	2	0	
77·09	Au.?	7	0·2	1	0	2	0·5	1	0	Au. on authority of British Association Catalogue, 1878.
76·32	...	8	0·3	1	1	...	...	...	...	March 11, 1886, 1·0.
...		3	0·9	3	2	2	1·0	2	2	Faint line just preceding *a* group.
70·16	...	9	0·3	1	0	1	0	0	0	Darkened twice. Unaffected May 6, 1889, and June 28, 1884.
69·35	...	10	0·3	1	0	1	0·5	1	0	Darkened once.
...		2	0·8	1	1	1	...	...	...	Obliterated in June spot, 1889. Faint line.
...		2	0·8	1	1	1	0·5	...	...	Faint line.
...						1	1·0	...	...	Faint line in spot.
64·31	Fe.	12	0·3	3	0	5	0·4	1	1	June 27, 1889, 1·0. June 20, 1889, ‡.
62·68	...	2	0·4	2	0	...	...	...	...	A line in A. Seems to be variable, as it has not been seen in solar spectrum on several occasions, though carefully sought for.
60·37	Ti.	13	0·7	12	2	10	1·1	7	4	June spot, 1889, ‡, 2·0 and 3·0, and on June 24 extended far into the penumbra.
57·84	...	13	0·5	7	0	12	0·8	12	3	May 6, 1889, 1·0. June spot 1·0 and 2·0, and ‡. (This group of Fe. lines always much widened in the minimum spots.)
55·51	Fe. + Ti.	13	0·4	5	0	12	0·7	11	2	June spot, 1889, 1·0, and ‡
53·40	Fe.	14	0·4	2	0	12	0·7	11	2	" " "
51·76	Fe.	14	0·4	2	0	12	0·8	12	2	June spot, 1889, 1·0 and 2·0, and ‡.
46·55 / *45·62	Fe. / Fe.	14	0·4	5	0	7	0·6	5	2	Close double June 20, 1889, 46·55, masked in spot. Twice 1·0, June 24 and 27, 1889. Unaffected June 14, 1884
43·49 / 42·60	...	14	0·7	11	1	15	2·1	15	10	A very remarkable double or triple in sun-spot spectra. For full discussion of observations vid. *infra*, p. 51.
40·51 / 39·42	...	14	0·5	11	0	6	1·1	5	4	‡ Feb. 28, 1887, June 27, 1889. 1·0 May 11, 1888, May 6, 1889, and June 26, 1889. 3·0 June 27, 1889. Darkened once.
*37·55 / 37·09 / 36·33	...	12	0·3	3	0	4	0·3	1	0	Triplet hard to separate in spots. Has a fuzzy appearance. Less dark over spot June 20, 1889. Unaffected June 28, 1884.

TABLE I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period.				Quiet Period.				Remarks.
		No. of Observations.	Mean Widening.	No. of times among More Widened Lines.	No. of times among Most Widened Lines.	No. of Observations.	Mean Widening.	No. of times among More Widened Lines.	No. of times among Most Widened Lines.	
*6231·72	Fe.	13	0·3	3	0	5	0·5	3	0	‡ June 27, 1889.
29·91	Fe.	13	0·3	1	0	6	0·5	4	0	,, ,,
28·35	...	3	0·5	2	0	3	0·5	2	1	May 6, 1889, 1·0. Obliterated in spot June 20, 1889. May 27, 1884, seen only across the spot; June 28 not seen at all.
25·62	...	9	0·6	8	0	3	0·7	3	0	
22·57	...	7	0·7	7	1	3	0·7	3	0	May 27, 1884, 1·0.
21·10	...	4	1·0	4	3	3	0·7	3	0	May 27, June 14, 1884, Feb. 6, 1886, 1·0.
*18·46	Ti.	10	0·3	1	1	3	0·4	2	0	Jan. 14, 1886, 1·0.
15·67	...	16	0·4	7	0	3	0·8	3	1	May 6, 1889, 1·0. Darkened once. } 1883. Twice, mean 0·3.
*14·30	Ti.	17	0·4	7	0	4	1·0	4	1	b Feb. 28, 1887. June 24, 1889, 2·0. Darkened once.
12·55	Fe.	18	0·3	2	0	3	0·6	3	0	
09·3	...	8	1·0	8	8	3	1·6	...	...	A faint line in A.'s map, but neither in his nor in B.'s catalogue. At max. always very much widened. On May 6 and 21, 1889, could not be seen at all in spectrum; on June 20, 1889, seen only across the spot and widened 5·0; on June 27 only in the spot. Seems to be a variable.
03·5(F.)	...	2	0·9	2	1	1	1·0	...	...	Not in A. May 27, 1884, only seen in the spot.
*6199·85	Fe.	17	0·3	3	0	4	0·8	2	1	June 24, 1889, 2·0.
...			0·9	8	5	3	0·9	3	2	A faint line widened both in max. and min. spots.
*90·71	Fe.	27	0·2	2	0	4	0·4	2	0	1883. Five times, mean 0·1. Darkened three times. June 14, 1884, unaffected.
87·26	...	13	0·4	6	0	2	0·8	2	0	Darkened twice.
85·4	...	10	0·4	5	0	2	0·8	2	0	,, ,, Not in A.'s catalogue, but on his map.
...		1	1·0	...	...	2	0·9	2	1	Faint line not in A. Perhaps F. 82·0.
79·46	Fe.	12	0·4	2	0	2	0·4	1	0	
75·95	Ni.	12	0·3	4	0	2	0·4	1	0	Unaffected June 28, 1884.
74·51	...	12	0·4	6	0	2	0·3	1	0	Darkened once. Unaffected, June 28, 1884, April 18, 1885.
72·49	Fe.	12	0·3	3	0	2	0·4	1	0	
69·59	...	45	0·3	1	0	8	0·4	4	0	Only five times 0·5 in fifty-three observations, once in max. in forty-five observations. Darkened once.
*68·48	Ca.	45	0·3	3	0	10	0·6	7	0	Darkened once. 1883, with 69·59. Ten times, mean 0·3. Darkened once.

Table I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period.				Quiet Period.				Remarks.
		No. of Observations.	Mean Widening.	No. of times among More Widened Lines.	No. of times among Most Widened Lines.	No. of Observations.	Mean Widening.	No. of times among More Widened Lines.	No. of times among Most Widened Lines.	
6165·62	...	30	0·6	22	11	10	0·9	9	4	Faint line. Darkened twice. May 6, 1889, 2·0, and widened far into the penumbra, June 24, 1889, 2·0, Sept. 12, 1883, 2·0.
63·95	...	13	0·4	4	1	7	0·6	4	3	Faint line. Obliterated July 1, 1886, in spot.
62·69	...	43	0·3	4	0	9	0·4	4	0	Steadily low. Darkened twice.
*61·40	Ca.	46	0·3	0	0	10	0·3	3	0	♯ June 27, 1889. „ „
60·23	Na.	19	0·8	16	7	13	0·5	7	2	This line is hard to separate from two preceding in Sun-spots. It often presents the appearance of a fuzzy band as in the spots of Oct. 3, Dec. 16 and 27, 1886, Jan. 28, Feb. 28, 1887, June 22, 1889.
56·90	...	11	0·4	5	0	2	0·2	1	0	Obliterated in spot June 20, 1889.
54·41	...									
53·89	...	12	0·5	10	0	2	1·4	2	1	A close triplet, seen as single in spots, June 20, 1889, 2·0.
53·33	Na.									
50·68	...	10	0·4	5	0	1	0·5	1	0	Darkened once.
...		2	0·9	2	1	1	0·8	1	0	Spot line. A band, June 25, 1885.
*48·28	Fe.	9	0·5	5	2	2	2·8	...	...	June 14 and 28, 1884, 1·0, June 20, 1889, estimated 5·0, extraordinary for a Fe. chromospheric line.
*46·76	...	6	0·2	0	0	...	...	...	...	Unaffected June 25, 1885. Not seen May 6, 1889. Glimpsed June 20, 1889. Possibly variable.
44·09	...	9	0·5	5	0	3	0·5	2	0	Obliterated June 20, 1889.
*40·81	Ba.	45	0·2	1	0	6	0·4	2	0	1883. Nine times 0·2. Darkened three times. Only three times 0·5 in sixty observations. Unaffected six times. ♯ June 27, 1889.
...		1	1·0	...	...	...	...	...	...	
36·82	...	48	0·3	0	0	6	0·4	3	0	1883. With 35·82. Fourteen times, mean 0·5. April 6 and Sept. 12, 1·0. Unaffected Dec. 22, 1887. ♯ June 27, 1889.
*35·82	Fe.	48	0·3	0	0	6	0·4	3	0	Unaffected Dec. 22, 1887. ♯ June 27, 1889.
...	...	5	0·9	5	3	2	1·4	2	2	Faint line 2·0 May 6, 1889. Neither in A. nor F. S. has the line.
30·59	...	12	0·4	3	0	2	0·7	2	0	
28·61	...	4	0·2	0	0	1	0·8	...	...	A very faint line, difficult to detect.
27·00	Ti.	15	0·5	7	1	2	0·5	2	0	
25·29	...	10	0·4	5	0	2	0·7	2	0	Darkened once.
23·92	...	9	0·3	1	0	2	0·4	1	0	Darkened once. Obliterated June 20, 1889.
*21·34	Ca. + Co.	51	0·4	13	0	10	0·5	5	0	1883. Fifteen times, mean 0·5. Sept 12, 1·0. ♯ June 27, 1889. Twenty-five times 0·5 in seventy-six observations. Co. less refrangible L. and D. F. does not resolve.

TABLE I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
6118·93	...	18	0·5	12	0	2	0·7	2	0	
15·51	Ni.	18	0·4	4	0	4	0·5	3	0	Ni. lines sharp, thin, and dark.
* 10·11	Ba.	18	0·5	12	0	2	0·7	2	0	
07·36	Ni.	17	0·4	4	0	4	0·5	2	0	1883. Once 0·7.
04·58	...	11	0·7	8	3	1	0·8	1	0	
* 01·92	Ca. + Li.	53	0·4	14	0	11	0·5	6	0	1883. Sixteen times, mean 0·4. ‡ June 27, 1889.
6099·08	...	16	0·4	5	1	2	0·3	1	0	Obliterated June 20, 1889. July 2, 1886, 1·0.
97·66	...	15	0·4	3	0					
95·20	...	13	0·3	2	0	2	0·5	2	0	
94·02	...	12	0·2	1	0					
92·42	...	11	0·4	5	0	1	0	...	...	Obliterated June 20, 1889.
90·59	Ti.	16	0·6	11	2	2	0·5	1	1	May 6, 1889, 1·0. Obliterated June 20, 1889.
88·42	...	17	0·4	4	1	1	0·5	1	0	Darkened once.
86·69	...	19	0·4	4	1	6	0·7	3	2	Very dark May 6, 1889.
85·10	...	11	0·2	0	0	4	0·5	4	0	The identification of this group of faint lines between 6101·92 and 6077·8 is somewhat doubtful. A. gives ten lines, K. eleven, B. twelve, F. sixteen, S. eighteen, and Thollon twenty-three. With twelve prisms and excellent definition fourteen lines have been seen, the grouping being as in S.
* 83·27	Ti.	18	0·3	2	0	4	0·5	4	0	
82·10	...	19	0·2	0	0	4	0·6	4	0	
80·4	...	15	0·5	10	0	6	0·6	6	1	1·0 Dec. 23, 1886.
77·80	Fe.	33	0·2	1	0	7	0·3	2	0	1883. Four times, mean 0·3. Steadily low. Darkened three times.
75·87	...	4	0·6	2	1	1	0·8	1	0	June 2, 1886, 1·0. A. draws a faint line. Seems to be variable, as frequently it could not be detected.
* 64·70	Fe. + Ti.	34	0·2	1	0	6	0·3	1	0	Only twice 0·5, June 14, 1884, and June 20, 1889, in forty observations. Darkened three times.
...		1	1·0	...	...	...	...	...	...	Perhaps F. 63·5.
61·7 (F.)	...	19	0·9	19	8	16	0·9	16	8	Always considerably widened both in max. and min. spots. A. faint line not in A.
...		5	1·0	5	5	...	...	...	...	Spot line.
55·29	Fe.	26	0·1	0	0	5	0·2	0	0	Darkened four times. When widened always slightly.
53·28	...	20	0·8	19	11	16	0·8	16	4	A faint line, among the most widened both in max. and min. spots.
...						1	2·0	...	...	Spot line May 6, 1889.

Table I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period. No. of Observations.	Disturbed Period. Mean Widening.	Disturbed Period. No. of times among More Widened Lines.	Disturbed Period. No. of times among Most Widened Lines.	Quiet Period. No. of Observations.	Quiet Period. Mean Widening.	Quiet Period. No. of times among More Widened Lines.	Quiet Period. No. of times among Most Widened Lines.	Remarks.
6041·37	...	18	0·2	1	0	5	0·2	0	0	Darkened once
39·4 (F.)	...	19	1·0	18	15	16	1·2	16	11	A faint line not in A. always considerably widened both in max. and min. spots. June 26, 1889, 3·0. Darkened once.
26·14	Fe.	26	0·3	3	0	4	0·4	1	0	Fe. lines in this region never much widened.
23·16	Fe.	25	0·3	3	0	4	0·4	2	0	
20·91	Mn.	25	0·3	4	0	4	0·5	2	0	
19·33	Fe.	25	0·3	3	0	3	0·4	1	0	
...		1	1·0	...	...	...	...	...	...	Spot line.
15·81	Mn.	27	0·3	5	0	3	0·5	2	0	
12·68	Mn.	27	0·4	4	0	3	0·5	2	0	
11·42	...	11	0·4	4	1	3	0·6	2	1	Feb. 6, 1886, 1·0. June 20, 1889, unaffected, June 26, 0·8 (same spot). Darkened twice.
07·65	Fe.	24	0·3	3	0	3	0·5	2	0	Darkened once.
...		18	1·0	18	13	2	0·5	1	1	Faint lines about 6004 generally very much widened. Unaffected June 20, 1889.
02·25	...	24	0·3	1	0	3	0·4	2	0	
5998·5	Ti.	19	1·0	19	14	3	0·9	3	2	A. has this Ti. line on his map, but neither in his or B.'s catalogue. Always much widened.
97·08	...	22	0·2	1	0	...	...	...	...	1883. Once 0·5. Darkened three times.
96·44	...	2	0·6	1	1	3	0·2	1	0	Sept. 29, 1884, 1·0.
*90·20 } 89·89 }	Telluric	11	0·3	2	0	3	0·4	1	0	Difficult to separate. Darkened five times.
88·10	Telluric	5	0·7	4	3	3	0·5	1	1	July 19, Aug. 10, Aug. 22, 1884, June 26, 1889, 1·0. Darkened once.
86·35	Fe.	17	0·2	0	0	3	0·2	1	0	Unaffected June 20, 1889, while two companion Fe. lines widened 0·3.
84·35	Fe.	21	0·2	2	0	3	0·4	1	0	Darkened once.
83·01	Fe.	21	0·2	1	0	3	0·3	1	0	,, ,,
...		1	1·0	...	...	...	...	...	...	Faint spot line.
77·27	Ti.	21	1·0	18	13	9	1·2	8	7	Aug. 10, 1884, July 2, 1886, 2·0. June 26, 1889, 3·0. Extended far into penumbra on several occasions. A faint Ti. line always very considerably widened.
76·23	Fe.	20	0·2	2	0	3	0·4	1	0	
74·79	Fe.	20	0·3	2	0	3	0·4	1	0	
70·44 } 69·22 }	Telluric	9	0·6	5	2	3	0·4	1	0	April 19, 1885, Jan. 8, 1886, 1·0. Darkened once.
67·35	...	19	0·4	6	0	3	0·6	2	0	Darkened once.

TABLE I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period.				Quiet Period.				Remarks.
		No. of Observations.	Mean Widening.	No. of times among More Widened Lines.	No. of times among Most Widened Lines.	No. of Observations.	Mean Widening.	No. of times among More Widened Lines.	No. of times among Most Widened Lines.	
5965·9	Ti.	18	0·5	11	1	3	0·7	3	1	In A.'s map, but not in his catalogue.
61·67	Telluric	8	0·7	6	2	1	0·8	1	0	June 12, July 19, 1884, 1·0.
57·22	...	17	0·3	1	0	2	0·2	0	0	
55·63	...	12	0·3	3	0	2	0·3	1	0	
53·94	...	7	0·4	3	0	2	0·7	1	1	Identification doubtful.
51·96	Ti.	16	0·4	5	0	2	0·5	2	0	
50·41	...	2	0·7	2	0					
48·44	Telluric	16	0·2	0	0	...	...	...	...	Darkened once.
47·62	Fe.	14	0·2	0	0	2	0·4	0	0	
45·97	Telluric triplet	12	0·3	1	0	2	0·1	0	0	Darkened four times.
44·98		12	0·3	1	0	2	0·1	0	0	,, ,,
43·62		12	0·4	3	0	2	0·1	0	0	,, ,,
41·71	Telluric	13	0·3	1	0	1	0·4	0	0	
40·9	,,	13	0·4	4	0	1	0·4	0	0	Darkened once. In A.'s map, but not in his catalogue.
40·43	,,	12	0·3	3	0					
37·44	,,	13	0·7	9	3	2	0·8	2	0	Darkened once. June 14, 1884, April 19, 1885, Feb. 6, 1886, 1·0.
35·05	,,	8	0·4	2	1	1	0·5	1	0	Feb. 6, 1886, 1·0.
34·03	Fe.	13	0·3	2	0	3	0·5	2	0	Darkened once.
31·76	Telluric	11	0·3	3	0	2	0·7	2	0	
31·18	,,	11	0·3	3	0					
29·46	Fe.	13	0·3	1	0	2	0·4	1	0	Darkened once.
27·37	...	13	0·4	5	0	2	0·5	2	0	
24·02 / 22·99	Telluric	9	0·4	5	0	1	0·5	1	0	
21·69	,,	9	0·6	8	0	...	...	...	...	A. has a line 20·87. Never seen at Stonyhurst.
19·09 / 18·4 / 17·51	,,	10	0·6	9	0	1	0·5	1	0	18·4 is on A.'s map, but not in his catalogue.
14·60	,,	9	0·6	7	0	...	...	...	...	Darkened once. Much widened in penumbra, July 25, 1885.
*13·30	Fe.	12	0·2	0	0	...	...	...	...	Darkened once.
09·72	Telluric	3	0·6	2	0					
04·56	Fe.	9	0·3	1	0					
5899·10	Ti.	9	0·4	2	0					
*95·13	Na. D_1	For special discussion vid. infra, p. 47.								

Table I.—(*continued.*)

Wave-Length.	Origin.	Disturbed Period.				Quiet Period.				Remarks.
		No. of Observations.	Mean Widening.	No. of times among		No. of Observations.	Mean Widening.	No. of times among		
				More Widened Lines.	Most Widened Lines.			More Widened Lines.	Most Widened Lines.	
5892·10	Ni.	32	0·3	7	0	8	0·3	1	0	Darkened once. Less dark over a spot, June 20, 1889. 1882–83. Four times mean, 0·4.
90·78	Telluric	11	0·5	8	1	6	0·3	2	0	April 18, 1885. 1·0. Obliterated over spot, June 20, 1889.
*89·12	Na. D_2	For special discussion vid. infra, p. 47.								
*83·19	Fe.	1	0·2	0	0	Observations taken in 1884.	...	...	...	Darkened once.
65·47	Ti.	11	0·3	1	0					
61·56	Fe.	10	0·3	0	0		...	...	...	Darkened once.
58·68	Fe.	3	0·5	2	0					
56·60	Ni. + Ca.	11	0·3	1	0					

Section II.

Behaviour of Metallic Lines in the Spectra of Sun-Spots.

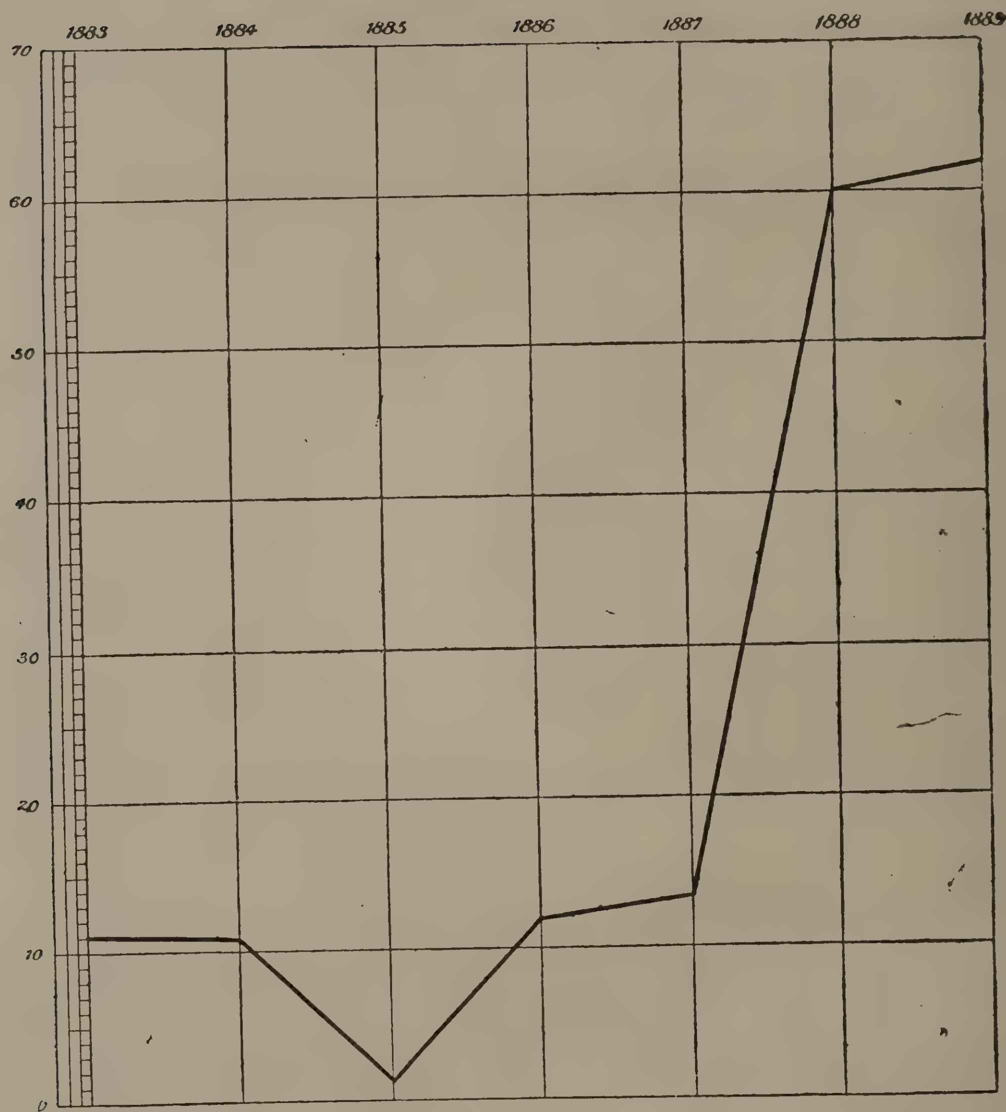
Iron.—The number of iron lines observed as affected in Sun-spots in the region of the spectrum under discussion is 53, and 11 of these are coincident with lines seen bright in the chromosphere by Young. In the disturbed period only one iron line, *6148·28, had a mean widening of 0·5, but in the observations taken since October 1886 some iron lines have always entered among the more widened lines, while the widening of nearly all the iron lines has increased. Among the lines which have been most affected are those in the group about w. l. 6250, while on the contrary the widening of the lines about w. l. 6000 has been invariably but slight. If the June spot of 1889 be excepted, only three iron lines have entered among the most widened lines; viz. *6430·12 on May 7, 1889, a line observed 31 times, 6314·18 on May 20, 1884, out of nine observations, and *6141·28 on June 14 and June 28, 1884, in eleven observations. In the June spot of 1889, in which many even faint lines of other substances were very much widened, nine iron lines were widened 1·0, one of these being *6430·12, three were widened 2·0, one

of these being *6199·85, while *6148·28 attained a width of 5·0, and presented in the spot the appearance of a broad, fuzzy band, which however was difficult to see. It will be remembered that this last is the only line which in the maximum period had a mean widening of 0·5. In YOUNG's list it has a frequency 3, and a brilliancy 2 (C = 100, 100) ; it is 1*b* in intensity and width on KIRCHHOFF's scale (F = 6*g*), and it is recorded in the arc but not in the spark spectrum of the metal.

The iron lines present great variations in the spectra of Sun-spots, the same lines not being affected in the same manner even in the same spot when observed on successive days. Nor is there any variation common to all in a spot on its second appearance, lines slightly affected before being now more widened and *vice versa*. No results could be obtained by arranging in parallel columns the iron lines widened in the same spot on successive days, or by comparing the second appearance of a spot with its first.

In general the lines seen bright in the chromosphere by YOUNG have been least affected in Sun-spots, three only of such lines having been recorded among the most widened lines. Whenever an iron line was unaffected in the large spots which were observed in 1884, it was coincident with a bright line in YOUNG's list.

In order to show the general increase in the widening of the iron lines in the quiet period of the Sun-spot cycle, the following table and curve has been constructed from the observations. In any given year a total number of observations of iron lines has been found by the addition of each observation of any one of these lines. Then the number of times that any line was among the more widened lines has been reckoned, and added together to form a second column. By this means a percentage curve has been drawn, although the number of observations of iron lines has been unequal in the different years. Such a method of forming a curve would be very faulty, were not the iron lines more or less evenly distributed throughout the whole of the region in which observations have been taken, so that although on any particular day time might not allow of the whole region B–D being studied, yet iron lines will certainly occur among the observed lines. Moreover, before commencing the detailed study of a spot, it has generally been the custom to quickly pass in review the whole region, so that any iron lines more than ordinarily widened could not have failed to have been recorded.



Percentage Curve, showing the number of times Iron lines were among the more widened lines in the Spectra of Sun-spots in the region B–D.

The close agreement of this curve with those given for iron from the South Kensington observations (*Proc. R. S.* vol. xlvi. No. 284, pp. 399, 400) is worthy of remark, although the curve has been deduced from observations taken in a different part of the spectrum on a different plan, and reduced in a different manner.

TABLE II.

Widening of Iron Lines in the Spectra of Sun-spots, in the region B–D.

Year.	No. of Observations.	No. of times more widened.	Per Cent.	No. of times most widened.
1883	82	10	12·2	0
1884	561	66	11·7	4
1885	126	3	2·4	0
1886	271	38	14·0	0
1887	36	6	16·7	0
1888	25	15	60·0	0
1889	127	81	63·8	14

Titanium.—Of the eleven titanium lines which occur in this region, three are coincident with bright lines, viz. *6214·30, *6218·46, and *6083·27; and the last two have been among the lines least affected in spots. In this category may be placed also the lines at 5951·96 and 5899·10. Judging, however, from the rest of the lines, titanium is remarkably affected in Sun-spots both at the maximum and minimum period, and the lines most widened are lines very faint in the solar spectrum. Among such the most remarkable are the lines 5977·27 and 5998·5, both of them recorded by THALÉN among the brighter lines in the spectrum of the metal. The average widening of these two lines, the first from 30, and the other from 22 observations, is about 1·0. The line at 6260·37 has likewise been very much widened in Sun-spots, the mean, however, being greater in the minimum than in the maximum, the former being 1·1 from 10, and the latter 0·7 from 13 observations. This line also is one of THALÉN's brighter lines in the metal spectrum. Another characteristic of some titanium lines is that they have been on several occasions widened far into the penumbra of Sun-spots, and at times apparently beyond,

on the photosphere. Among such are 5977·27, frequently so affected (*e.g.* May 27, 1884; July 2, October 3, 1886; June 24, 1889), 6260·37, which on June 24, 1889, was widened 3·0, and extended far into the penumbra, and the quiet line 5951·96, which on January 14, 1886, was widened right through the penumbra on to the solar surface. Among my notes for June 4, 1884, occurs the entry: "Titanium lines in this and previous few spots very much widened." It is worthy of remark that Young has recorded a like phenomenon in the spectrum of a spot on April 9, 1870 (quoted in Lockyer's *Solar Physics*, ed. 1874, p. 564): "I was greatly surprised at the prominence they (the Ti. lines) assume in the spot-spectrum, as they are inconspicuous in the normal spectrum." Eight of the eleven titanium lines in this region have been recorded as widened 1·0; *6214·30 (June 24, 1889) and 5977·27 a faint line (three times) have reached 2·0, while 6260·37 (June 27, 1889) and 5977·27 (June 26, 1889) have had a widening of 3·0 their normal breadth. The line 6090·57 was obliterated across the spot of June 20, 1889. Finally all these lines especially mentioned as most widened are among the brighter lines in the spectrum of the metal.

Calcium.—Of the seven calcium lines observed, two, *6168·48 and *6161·40, have coincident bright lines in the spectrum of the chromosphere. The variation in the lines due to this metal is, with a few exceptions, not great, although in the minimum spots the mean widening has increased. Comparing the two lines 6492·41 and *6161·40; both are thick lines in the solar spectrum, and both are among the brightest long lines in the spectrum of the metal, but the widening of 6492·41 has been much greater than that of the chromosphere line, which has remained low throughout sixty-two observations. In the June spot of 1889, 6492·41 was widened 3·0. The only other calcium line found among the most widened lines is 6468·78. Five "basic" lines have calcium as one component, and three of these furnish eleven examples of a widening of 1·0 or more. Two of these three are chromosphere lines, viz. *6461·98 (Ca + Fe), and *6438·35 (Ca + Cd). So that while "basic" lines of which calcium is a component, and which are coincident with chromosphere lines, have been recorded among the most widened lines, pure calcium lines having coincident bright lines have not entered into this category.

Sodium.—Beside the D lines, the lines 6160·23, and 6154·4, which are long bright lines in the spark spectrum, occur in the region under discussion. The latter is a "basic" line having a coincident iron line. Observed fourteen times, its mean widening places it among the more widened lines. The line 6160·23 adjoins a calcium line, and it has been on several occasions very much widened, the widening presenting the appearance of a fuzzy band, through which at times the calcium line could be well traced as much the less widened of the two lines. With a moderate dispersion the two lines appear as one, and it might easily be erroneously inferred that the calcium line was very much widened. The appearance of the fuzzy band was particularly noted on October 3, December 16 and 27, 1886; January 28, February 28, 1887; and in the June spot of 1889.

The D lines have been observed over Sun-spots on 73 occasions in the disturbed period, and on 17 in the quiet period. In the maximum epoch the widening has varied from 0·1 to 1·0, the latter value having been recorded for D_1 on four, and for D_2 on five occasions. The mean widening of D_1 for the same period was 0·4, and for D_2 slightly greater 0·42, although D_1 was more widened than D_2 on April 10, 1882, and on April 6, 1883. For the minimum the range of widening is from 0 to 0·4 and the mean falls to 0·2 for both the lines. They have been less dark over spots on March 31, September 12, 1883; May 11, September 11, 1884; July 25, 1885; March 11, July 2, 1886; June 20 and 26, 1889; while they were unaffected over the spots of October 2 and 3, and of December 16, 1886. In the disturbed period the lines have also frequently been surrounded by a fuzzy haze, and on April 8, 1884; and April 18, 1885; were more widened on the violet side. Displacements towards the violet were noted on April 4, September 11, 1884, on June 9, 1885, and on June 26, 1889. In a spot of May 20, 1882, they appeared broken at one extremity of their length, and displaced seemingly towards the violet. On April 6, 1883, while one extremity of the lines was displaced towards the red, the other was bent towards the violet. On October 22, 1883, they were widened only over one part of the nucleus of the spot, and were also slightly twisted. The amount of widening varied in a short time in the spot of August 10, 1884, while on September 11 of the same year a variation in the intensity of the lines over different parts of the spot was remarked. They were obliterated in the darkest part of the

nucleus of the spot of March 11, 1886, and partially so on December 16, 1886.

In the large spot (S. F.) of September 29, 1884, the widening was in the form of a fuzzy haze, the dark lines standing out plainly in the centre of the haze, and being reversed at one portion of their length. The next day the lines were also just reversed. On July 25, 1885, the fuzziness of the lines was remarked even on the photosphere, with a reversal over the spot. Reversals were also recorded on January 14, and July 1, 1886.

Barium.—Of four barium lines observed, three are common to spots and the chromosphere. Two of the lines are long and bright in the spectrum of the metal, and these have been less widened than the other two which are shorter lines. No barium line has been among the most widened lines. Two "basic" lines have barium as one component, one 6449·29 with calcium, and the other 5904·6 with iron. The former line, observed thirty-eight times, was very steady until the May and June spots of 1889; the latter, observed nine times at the maximum, was also very steady.

A bright line of barium *6018·0 seen by Young in the chromosphere, has never been seen even among the ordinary Fraunhofer lines. Only once was a line seen in a spot, which was near in position to this line.

Nickel.—The four nickel lines have no corresponding bright lines in the chromosphere. They have never entered amongst the most widened lines, although the line between the D lines has been observed 44 times. They are all short lines, the longest being 3 on Lockyer's scale (1 to 4). On June 28, 1884, the longer was unaffected over a spot, while the two shorter were widened. The line between the D lines was less dark over a spot on June 20, 1889.

Manganese.—The three manganese lines are all long bright lines in the spectrum of the metal. In the spot spectra they have never been recorded among the most widened lines.

The "Basic lines."—The following Table exhibits the behaviour of the "basic" lines between B and D in the spectra of Sun-spots.

TABLE III.

The "Basic" lines between B and D in Sun-spot Spectra.

Wave-Length.	Origin.	Intensity and Character in the Spark.		No. of times observed.	No. of imes 1·0 max. and min.	
†5904·56	Fe + Ba	Fe (arc) 1 s	Ba 2 sd	9	0	...
†*6064·70	Fe + Ti	Fe 8 sd	Ti 8 sc	40	0	0
†*6101·92	Ca + Li	Ca 8 sc	Li 6 sc	80	0	0
†*6121·34	Ca + Co	Ca 10 sc	Co 6 sc	76	1	0
†6154·41	Fe + Na	Fe (arc)	Na 8 sc	14	0	1
†6255·51	Fe + Ti	Fe (arc) 1 s	Ti (A's map)	25	0	2
*6346·34	Ru + Ir	Spark Kirchhoff		9	0	0
†6407·38	Fe + Sr	Fe (arc)	Sr 10 sc	34	0	0
†*6438·35	Ca + Cd	Ca 10 sc	Cd 10 sc	42	0	3
†6449·29	Ca + Ba	Ca 10 sc	Ba 6 sd	38	0	4
†*6461·98	Fe + Ca	Fe (arc) 1 s	Ca 10 sc	40	0	4

In the first column lines marked with an asterisk have been seen bright in the chromosphere by YOUNG; those marked with a cross have been resolved into their components either by FIEVEZ, HIGGS, or by LIVEING and DEWAR. In the third column the intensities are on a scale from 1 to 10, while s means that the line is sharp, c that it is continuous or long, d that it is discontinuous or short.

From the table it is apparent how very rarely "basic" lines have been seen among the most widened lines, only once in the disturbed period, and fourteen times in the quiet period out of a total of 407 observations. Of these fourteen, eleven are due to the lines of which calcium forms one component. The appearance of "basic" lines among the more widened lines is about 31 per cent.

Section III.

Lines of unknown origin between B and D in the Spectra of Sun-spots.

A glance at Table 1 will show that in the disturbed period of the spot-cycle a great number of faint lines not in Ångström's map were to be seen among the most widened lines in the spot-spectrum. These lines disappeared during the quiet period in the small spots which were then prevalent, but the majority reappeared again in the spot of May 6, 1889, and to a greater extent in the June spot of the same year, which appeared on the Sun at almost the minimum epoch of the last cycle. The observation of the spectrum of this spot only served to strengthen the conclusion which Father Perry and the writer stated in a previous paper, on the "Comparison of the Spectrum between C and D of a Sun-spot observed May 27, 1884, with another of May 7, 1889" (*Monthly Notices, R.A.S.*, Vol. xlix. No. 8), that "the widening of the faint unknown lines of the solar spectrum is common to the minimum and maximum Sun-spot period." The curve of solar activity dropped very much after the July spots of 1886, in which the faint lines observed among the most widened lines were very numerous. On October 2 of the same year the spectrum of a small spot on the Sun was observed, and a note was entered in the Journal that the lines most widened were the ordinary Fraunhofer lines. But an opinion was added, to the effect that, should a large spot be observed in the quiet period, the faint unknown lines would reappear, and that their appearance and disappearance is not a characteristic of the maximum and minimum epochs, but of large and small spots. Their great preponderance in the time of maximum is solely due to the fact that the spots at that period are generally much larger than at the minimum. The reappearance of the lines in the large spot of June 1889, fully justified the opinion expressed three years earlier.

Some faint lines not in Ångström's map, and others among the faintest drawn in the map, have been persistently among the more and most widened lines in nearly every Sun-spot, large or small, observed either at the maximum or at the minimum epoch.

A table of a few of these lines is appended :—

TABLE IV.

List of Faint Lines always much widened in Sun-spots.

Wave-Length.	No. of Observations. Max. Period.	Min. Period.	Mean Widening. Max. Period.	Min. Period.	Limits of Widening. Max. Period.	Min. Period.
6571·4	22	7	1·0	0·9	0 to 3·0	0·5 to 2·0
6242·60	14	15	0·7	2·0	0·3 to 2·0	0·7 to 5·0
6165·62	31	10	0·6	0·9	0 to 1·0	0·3 to 2·0
6061·7 (F.)	19	16	0·9	0·9	0 5 to 1·0	0·7 to 1·5
6053·28	20	16	0·8	0·8	0·4 to 1·0	0·5 to 1·5
6039·24 (F.)	19	16	1·0	1·2	0 to 2·0	0 6 to 3·0

The great widening of the last three lines given in the table was independently noted both by Father PERRY and the writer. These three lines, with the line 6075·87, just precede on the more refrangible side four well-marked lines in ÅNGSTRÖM'S map, and, occurring in a part of the spectrum free from atmospheric lines, they were selected for constant scrutiny. Of these the line 6075·87 has been the most difficult to see in the spots, although it is marked in the map, the two not marked in the map being much easier to see. This line could not be seen at all on January 28, 1887, and on May 6 and June 20, 1889, even in the ordinary spectrum. It may possibly be variable. The two at 6061·7 and 6039·24 in the map of FIEVEZ have at times been traced in the ordinary spectrum, but even when they could not be traced they have stood out conspicuously in the spot-spectrum.

The double at 6242·60, 6243·49 is an extraordinary line in the spectra of Sun-spots. On June 14, 1884, the widening of the pair was estimated at 2·0; on October 3, 1886, when the estimated widening was 1·0, it was noted that it presented the appearance either of a small band on the more refrangible side of the pair, or that the line at 6243·49 was much displaced. On December 23, 1886 (widened 2·0), the widening was seen only on the violet side of the pair, almost seeming to indicate the existence of a faint line more refrangible than either component. The two lines are generally difficult to separate in Sun-spots. On February 28, 1887, the definition was so excellent that the spectrum of the mottled surface of the Sun could be distinguished as a series of alternate bright and dark horizontal strips. On this

day it was seen that 6243·49 was unaffected in the spot, and the widening was due either to 6242·6 being very much displaced to the violet, or to the possible existence of a faint spot line.* The appearance presented was that of a black bead clinging to the violet side of the dark line. On December 22, 1887, it was noted in the Journal "bead on violet side," and on May 11, 1888, "blotch on violet line." On May 6, 1889, the more refrangible component was widened 3·0, the other being unaffected. In the June spot, 1889, the widening of the two lines, seen in the spot as one, varied between 0·7 on the 20th, to 5·0, with an apparent displacement to the violet, on the 27th.

Grouping together all observations of lines due to unknown substances, whether faint or otherwise, the following table has been constructed :—

Table V.

Lines of Unknown Substances in the Spectra of Sun-spots between B and D.

Year.	No. of Observations.	No. of Times among more Widened Lines.	Per Cent.	No. of Times among most Widened Lines.
1884	862	312	36·1	66
1885	262	87	33·2	20
1886	576	262	45·5	65
1887–89	388	250	64·4	74

This table is not so reliable as that given for the iron lines, because, unless the whole spectrum between B and D be carefully observed on any particular day when observations are taken, it is quite possible that many faint spot lines might escape detection, which, had they been recorded, would have considerably altered the results.

Five chromospheric lines coincide in position with unknown lines in this region, and the mean widening of all has been low, only one, *6454·09, having been widened 1·0 on July 7, 1886. Of the rest, *6415·9 has been obliterated over spots on May 6, 1886, and on June 20, 1889, and was less dark on July 4 and 7, 1886 ; and *6237·55 was less dark on June 20, 1889.

* [Note added January 29, 1891.] This suspected line, slightly more refrangible than 6242·6, is clearly shown on two magnificent photographs of this region, taken at 5.50 A.M. August 28, and at 10 A.M. August 17, 1890, and kindly placed at my disposal by Mr. G. Higgs of Liverpool. It was this line most probably which was so very much affected in the spot-spectra.

At 6209·3 Ångström draws a very faint line. In the maximum period it was observed eight times, being widened 1·0 each time. In the minimum it seems to have disappeared except in spots. On May 6, 1889, it could not be seen ; nor on May 21, when a special search was made for the line, and a map was drawn. Neither Fievez nor Piazzi Smyth has a line in this position, while Thollon draws an exceedingly faint line. On June 20 and 27, 1889, there was no trace of the line in the ordinary spectrum, and yet it was prominent in the spot.

Another well-marked line in Ångström's map is 6262·68, recorded as widened twice in 1884. But it seems to have disappeared since, for it could not be seen even in the ordinary spectrum when looked for on one occasion in 1885, on two in 1886, on two in 1887, on one in 1888, on three in 1889, and on two in 1890, although on one of these last occasions it was searched for with the grating spectrometer. The line does not occur in the maps of Fievez or of Smyth, but Thollon has an exceedingly faint double apparently in this position.*

Section IV.

The C and D_3 Lines in the Spectra of Sun-spots.

The C line has been observed in 56 spots. In the disturbed period 41 observations were made, and the line was widened 16 times, the mean being 0·3, while it was only 4 times among the more widened lines. It was unaffected 10 times, it was 13 times less dark, and 5 times reversed. In the quiet period, in 15 observations the line was only once widened (0·2), it was unaffected 9 times, less dark 4 times, and once reversed.

When spots have been near the limb of the Sun, on several occasions the bright chromospheric line has been observed to be very stumped at the base, and has been easily traced as a bright band over the photosphere down to the spot, the black Fraunhofer line running through the bright band.

On December 23, 1886, the dark line in the bright band was less dark where it crossed the spot ; on May 11, 1888, on the contrary, the dark line thinned just before reaching the spot, and was widened over the spot, the

* [Note added January 29, 1891.] Neither 6209·3 nor 6262·68 has any existence on Mr. Higgs' photographs.

prominence line being displaced to the violet. On June 27, 1889, the broad red band surrounding the dark line was of greater width on the less refrangible side, while the black line, unaffected in the spot, was almost reversed in the regions surrounding the following side of the spot. Both on May 12, 1882, and on April 7, 1884, the prominence over the spot was displaced towards the red. On March 28, 1883, the black line was displaced towards the violet.

On August 22, 1884, the line was reversed over a scattered group of small spots near the centre of the disc. At 4.10 P.M. the reversal was first detected, and it occurred, not in the spots themselves, but in the faculæ between them. Each spot of the group was then brought on to the slit to corroborate this result, when, besides the reversals in the faculæ, a bright red dot was noticed in the umbra of one of the small spots in the following part of the group. All the reversals were very bright. At 4.55 the phenomenon was no longer visible, but when the Sun was examined by the telescope on succeeding days, it was observed that a great development in the group had taken place in exactly that portion where the reversals were noted.

A reversal was observed on September 12, 1884, in a group containing two principal spots. The line was reversed on the disc in advance of the preceding member of the group, the dark line being distorted towards the red; while in the spot itself the red and black lines were seen side by side, the black line fainter than usual, and the red line displaced to the less refrangible end of the spectrum. This was at 2.10 P.M. At 2.30 P.M. a change had taken place, C being reversed in the penumbra, but now displaced towards the violet. At 5.30 P.M. the line was obliterated and just reversed in the faculæ between parts of the group, and likewise obliterated in the penumbra.

On September 20, 1884, the Fraunhofer line was of varying thickness where it crossed the spot, and just reversed in parts. A reversal was also noted on September 12, 1883. On January 14, 1886, the line was reversed over a spot, and the black line near the spot was displaced to the red. On February 28, 1887, the line was reversed between the principal spot and a small member of the group, as also in the nucleus of the small spot, with a displacement to the violet.

The line D_3 was seen as a bright line over a large spot on March 31, 1883, and on June 6, 1885, when a spot was near the limb, the line was exceedingly bright in the chromosphere over the spot, and distinctly traceable as a bright line far into the photosphere. These observations of D_3 were both made by Mr. W. McKeon.

Section V.

Various Observations on the Spectra of Sun-spots between B and D.

1. Several of the lines marked as telluric by Ångström, or as affected by our atmosphere, have been observed to be widened in spots. These observations have been corroborated by more than one observer. The two triples at 5940·0 and 5944·0 have been very carefully watched. Even with the Sun on the meridian and at a high altitude they are to be seen in the ordinary spectrum. One telluric line in this region, *5990·20, has been recorded as a bright line by Young, with a frequency 10, and it has been the least widened of all telluric lines in spots. A possible explanation of the widening of telluric lines in Sun-spots may be that faint solar lines exist very near in position to such lines, and it is really the widening of these latter which has been noted.

2. On some occasions the general absorption given by a spot has been so very dark as to mask all the phenomena of selective absorption in the lines. Such was the case in a spot on the N. F. portion of the Sun's disc on May 11, 1884; as also on May 18, 1884, in a spot S. P. The same appearance was seen on July 25 in the region of the spectrum about w. l. 6172·5. On February 6, 1886, the general absorption at the red end was much darker than in the rest of the spectrum.

3. A curious phenomenon observed sometimes is that, while the great majority of the lines present, when widened over the penumbra and umbra of a spot, the usual spindle-shaped appearance, some few have been of the same thickness throughout—*e.g.* on January 14, 1886, when an iron line at 6026·14 was affected in this manner.

4. On several occasions lines have been noted as remarkably widened in the penumbra of spots. Attention has already been called to some titanium lines often affected in this manner. Among other lines the following may be noted: 5892·50 (Ni), 6172·49 (Fe), 6118·93, 6165·62, 6039·4 (Fievez), 6203·6 (Fievez), and 5914·6. On May 11, 1884, in a large spot S. P., all the lines observed were widened far into the penumbra; but in the same spot, when observed seven days later, the lines could not be followed in the penumbra. On March 11, 1886, *6101·92 (Ca), *6121·34 (Ca), *6135·82 (Fe), and *6140·81 (Ba) were noted as remarkably widened in the penumbra.

5. The spectrum of faculæ surrounding spots, and bridges in spots, has been carefully scrutinised for reversals on several occasions. The dark Fraunhofer lines have never been widened in the bright continuous spectrum given by faculæ and bridges, and, beyond the reversals of the C line in faculæ described above, no others have been recorded. The bright continuous spectrum is, however, much brighter than the ordinary solar spectrum.

6. The spot-bands described in my paper, "Bands observed in the Spectra of Sun-spots at Stonyhurst Observatory" (*Monthly Notices*, *R.A.S.*, Vol. xlvii. No. 1), which were first seen at the beginning of 1885, disappeared synchronously with the dropping of the Sun-spot curve in the autumn of 1886, and since October 1886 they have never been observed at Stonyhurst up to the time of writing (September 1890), not even in the fine spot of June 1889. Since writing the former paper, however, the band described (*loc. cit.* p. 21) as adjoining the line w. l. 6379·99 has been identified with a band in precisely the same position (764·2 of Kirchhoff's scale) drawn by Young in 1872 (*Nature*, December 12, 1872). Such independent testimony to the existence of this band renders the observation more valuable. The bands were observed on eight occasions, four of these instances being due to the same spot, observed on different days. A study of the life-history of these spots from the Stonyhurst drawings has been kindly made for me by Mr. W. McKeon. In every single instance in which spot-bands were detected, the spot was either a spot of long duration, or the revival of an old disturbance.

Measures of Double Stars made at Sydney Observatory in the Years 1882–1889. Communicated by H. C. Russell, B.A., F.R.S., Government Astronomer.

[Received February 9; read March 13, 1891.]

The following list contains the double-star measures made at Sydney Observatory from the beginning of 1882 to the beginning of 1890, with the exception of those of some new stars published in 1883.

It has been prepared by Mr. J. A. Pollock, assisted by Mr. Sellors.

The observations were principally made during the years 1882, 1883, 1886, 1887, and 1889. The measures of a few stars published in the *Monthly Notices of the Royal Astronomical Society* for June 1887 are included for the sake of completeness.

The positions of those stars which are found in Stone's Cape Catalogue for 1880, or in the Argentine General Catalogue, have been brought up to 1900 by Mr. Sellors. The positions of the other stars are approximate only. The measures marked R have been made by Mr. Russell with the 11½-inch telescope; those marked Hr by Mr. Lawrence Hargrave with the 7¼-inch telescope; and those marked Pk by Mr. Pollock. Of these latter those during 1886 were made with the 7¼-inch telescope, and all others with the 11½-inch. In the first column, under "Name," is given the star's constellation name and its number in the Double-Star Catalogue where previously measured. The number of those stars measured by Sir John Herschel has been given from his list of "Results of Observations of Double Stars made

with the 20-foot Reflector," in the volume of Astronomical Observations made at the Cape of Good Hope. The other references are :—

Santiago.—A catalogue of 1,963 stars, and of 290 double stars, observed by the U.S. Naval Astronomical Expedition to the Southern Hemisphere during the years 1850, 1851, 1852.

Washburn.—A list of new double stars in vol. ii. of the Publications of the Washburn Observatory.

β.—Burnham's catalogues of new doubles.

Syd. 1 and Syd. 2 refer to two lists of new double stars found at Sydney Observatory, published in 1882 and 1883 respectively.

Note to Mr. Pollock's *Measures.*

In all measures by Pk subsequent to 1886 the line joining the eyes has been either parallel or at right angles to the line joining the two stars. The stars have in all cases been measured within two hours of the meridian ; and an endeavour has been made to make A.M. and P.M. observations of each star equally numerous. Three eyepieces were used with the $11\frac{1}{2}$-inch telescope, giving powers respectively of 167, 333, and 800. Where circumstances permitted, the measures of the same star on different nights have been made with different eyepieces.

Of the stars measured the following seem to be the most decided instances of motion, excepting, of course, the well-known stars p *Eridani*, *a Centauri*, and γ *Coronæ Australis*. The measures of the various observers have been brought together for convenience.

The abbreviations for observers' names are as follows :—

Dp = Dunlop	h = Sir J. Herschel	Ja = Jacob	Po = Powell
El = Ellery	T = Tebbutt	β = Burnham	R = Russell
Hr = Hargrave	Pk = Pollock		

Name.	R.A. 1900.	S. Dec. 1900.	Obs.	Date 1800+.	Pos. Angle.	Dist.	Magnitudes.	
	h m	° ′			°	″		
h 3949	2 15·6	35 54	h	37·909	122·6	1½ est.	9–9	3 *n*.
			Pk.	87·936	75·6	1·42		1 *n*.
h 3835½ *	6 2·2	48 27	Dp.	26·00	329·0	3·0	...	...
			h	35·016	342·5	3·86	8–8	1 *n*.
			h	36·878	343·5	...	8–8	1 *n*.
			Ja.	46·76	347·6	3·33	6·5–7	2 *n*.
			Ja.	47·24	349·6	2·98		1 *n*.
			Ja.	56·227	353·9	2·28	6·7–6·7	2 *n*.
			Ja.	56·756	354·2	2·33	7–7	2 *n*.
			Ja.	57·200	355·0	2·23		3 *n*.
			Ja.	57·884	355·4	2·16	7–7	2 *n*.
			Ja.	58·172	354·7	2·18	7·5–7·5	4 *n*.
			R.	73·063	2·1	2·90	7–7	1 *n*.
			T.	81·215	11·4	2·46	8·3–8·5	2 *n*.
			R.	82·183	11·7	2·35	7–7	1 *n*.
			T.	82·318	21·6	...	8·3–8·5	5 *n*.
			T.	85·185	19·8	1 est.	7–8	2 *n*.
			T.	87·417	24·2	1·95	8–8·3	3 *n*.
			Pk.	88·091	19·8	1·66	8–8·2	2 *n*.
			Pk.	90·019	26·4	1·61	7–7·5	1 *n*.
h 3886	6 37·6	62 6	h	34·983	341·0	12 est.	9–11	1 *n*. A 3rd star nf.
			Hr.	83·162	220·6	28·19	9–10	1 *n*. A 3rd star nf.
h 4373	10 43·8	40 54	h	35·164	226·1	25 est.	8–9	1 *n*.
			Hr.	82·329	339·1	10·44	9–10	1 *n*.
h 4433½	11 15·1	61 0	h	38·099	296·8	6·43	8–9	2 *n*.
			Hr.	83·422	337·9	2·41	9–10	1 *n*.
h 4475	11 43·7	60 59	h	34·244	125·4	2 est.	10–11	1 *n*.
			Hr.	82·465	326·7	5·14	10–11	1 *n*.
γ Centauri	12 36·0	48 25	h	35·32	351·6	...	...	
			h	35·89	354·3	0·75	4–4	
			h	36·38	357·3	...	...	
			Ja.	56·200	20·6	0·7 est.	3·5–4	3 *n*.
			Ja.	57·973	13·71	1·11	3–3·5	5 *n*.
			Po.	60·684	12·8	...	3–3·5	10 *n*.
			Po.	70·233	6·9	1·5 est.	...	6 *n*.
			R.	71·386	3·8	1·18	4–4	1 *n*.
			R.	73·364	4·2	2·29	4–4	1 *n*.
			R.	74·260	1·6	1·61	...	1 *n*.
			El.	76·63	8·5	1·3	...	
			R.	80·444	1·3	1·39	4–4	1 *n*.
			T.	87·583	359·1	1·76	4–4	2 *n*.
			Pk.	87·526	358·5	1·75	...	6 *n*.

* *h* 3835½, Mr. Tebbutt in 1881 drew attention to the variability of this star.

Name.	R.A. 1900.	S. Dec. 1900.	Obs.	Date 1800+.	Pos. Angle.	Dist.	Magnitudes.	
	h m	° ′			°	″		
γ Centauri	12 36·0	48 25	T.	88·474	359·5	1·87	4–4	4 *n.*
			Pk.	89·323	359·1	1·73	...	4 *n.*
β Muscæ	12 40·1	67 34	R.	80·344	317·3	0·54	4–4·5	1 *n.*
			R.	86·549	322·9	0·79	...	2 *n.*
			Pk.	86·594	325·8	0·5 est.	...	1 *n.*
			Pk.	87·552	326·5	0·89	...	7 *n.*
			T.	88·337	329·3	1·26	4–4	2 *n.*
π Lupi	14 58·3	46 40	h	35·37	112·8	...	5–5	
			h	36·11	111·1	0·75		
			h	37·04	108·6			
			Ja.	48·12	106·3	1·20 est.	5–5·5	1 *n.*
			R.	72·422	100·1	0·57	5–5	1 *n.*
			R.	80·444	99·3	0·90	5–5	1 *n.*
			R.	86·570	93·0	0·56	...	1 *n.*
			Pk.	86·575	90·5	0·87	...	1 *n.*
			Pk.	87·574	87·2	1·24	...	4 *n.*
			T.	88·654	86·3	1·50	...	1 *n.*
h 4917	17 2	54 12	h	34·518	331·1	7 est.	8–12	1 *n.*
			h	36·356	324·4	9 est.	8–12	1 *n.*
			Pk.	87·689	348·6	11·82	8·5–12	2 *n.*
β 416	17 12	34 53	β	76	240 est.	1·8 est.	6–8·5	
			R.	77·643	224·4	1·77	7–9	1 *n.*
			β	89·25	137·4	1·48	6·3–7·5	4 *n.*
			Pk.	89·630	131·9	0·97	...	1 *n.*
h 5027	18 5	54 23	h	34·518	59·2	15 est.	8–9	1 *n.*
			R.	71·548	84·7	12·98	8·5–9	1 *n.*
			Hr.	81·706	91·8	11·42	9–10	1 *n.*
			Pk.	86·597	95·2	12·90	...	1 *n.*
			T.	87·750	97·4	11·84	9–10	3 *n.*
			Pk.	89·670	98·5	12·27	...	3 *n.*
h 5031	18 6·6	47 21	h	34·498	101·2	18 est.	9–9	1 *n.*
			Hr.	82·704	87·0	23·35	9–9·5	1 *n.*
β 762	20 10·6	32 5·5	β*	79·717	42·6	3·8	8–8	
			β*	79·742	20·7	2·4	8–9	
			Pk.	87·718	303·8	2·78	8–8	4 *n.*
h 5295⅔	21 41·7	47 45	h	36·65	14·2	30·30	6–9	2 *n.*
			Ja.	46·42	10·3	31·11	...	1 *n.*
			Ja.	56·802	7·15	33·91	6–9·7	2 *n.*
			Hr.	81·816	2·7	39·79	5–9	1 *n.*
			Pk.	86·605	2·0	42·35	...	1 *n.*
			Pk.	89·725	1·4	43·35	...	4 *n.*

* β notes, "These measures disagree so much that possibly they may belong to different objects."

γ Lupi was examined on three nights with the following result : —

R 1886·570. "Examined this star with 800 power. Fancy it is elongated in direction 90°, but am very uncertain. Definition not good."

Pk 1886·570. "Round with all powers on $7\frac{1}{4}$-inch telescope."

Pk 87·531. "*γ Lupi* single, with 800 power on $11\frac{1}{2}$-inch. Never saw definition better. The star-image is triangular, apex at angle of 210° ; the other angles are also well marked." In a note to *ζ Sagittarii*, which was measured on this night, Pk says, "*γ Lupi* is not like this star."

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800 +.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
Syd. 1–3	A G C 395	0 23·7	66 28	Pk.	87·934	238·6	1·47	8–9	A and B
				Pk.	87·936	238·0	...	...	
				Pk.	87·939	239·7	...	...	
				Pk.	89·887	240·9	1 est.	...	
h 3370	...	...	...	Pk.	89·769	62·9	39·52	8–9·5	A and C
				Pk.	89·783	62·9	39·64	...	
h 3376	St. 200	0 28·8	55 53	Pk.	87·895	246·4	6·22	7–10	
				Pk.	87·925	246·3	6·79		
Syd. 1–4	A G C 513	0 30·5	54 6	Pk.	87·928	93·5	2·76	8–9	
				Pk.	87·950	93·0	2·15		
β 395	St. 225	0 32·2	25 19	Pk.	88·011	109·4	1 est.	7–7	
ξ Phœnicis *h* 3387	St. 262	0 37·2	57 3	Pk.	86·871	253·8	12·60	6–11	
				Pk.	87·830	252·0			
				Pk.	87·871	253·0	12·62		
	St. 265	0 37·4	56 20	Pk.	86·871	163·4	7·22	7–9	
				Pk.	87·791	163·6	5·99		
				Pk.	87·830	164·4	5·58		
η Phœnicis *h* 3391	St. 280	0 38·9	58 1	Pk.	87·871	217·7	20·10	4·5–11	
h 3395	St. 303	0 41·0	42 27	Pk.	89·767	72·6	7·57	8–8·5	
				Pk.	89·786	73·4	7·31		
Santiago 4	St. 350	0 48·8	61 37	Pk.	87·895	71·3	5·61	8–8·5	
				Pk.	87·898	71·5	5·41		
Santiago 9	St. 462	1 7·0	73 29	Pk.	87·928	354·0	3·87	7–11	
				Pk.	87·934	355·6	4·09		
κ Toucani *h* 3423	St. 496	1 12·4	69 24	Pk.	86·912	359·7	5·58	5·5–8	
				Pk.	87·895	355·0	4·70		
				Pk.	87·925	355·8	4·97		

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
κ Toucani h 3423	St. 496	1 12·4	69 24	Pk.	87·928	356·3	5·11		
				Pk.	89·810	356·3	5·31		
				Pk.	89·813	355·3	5·07		
				Pk.	89·821	353·4	5·16		
h 3426	St. 502	1 13·6	66 56	Pk.	87·871	340·5	2·10	6·5–8	
				Pk.	87·893	337·5	1·69		
h 3427	...	1 15	50 40	Hr.	82·988	134·9	20·24	9–10	
h 3428	A G C 1270	1 16·0	49 12	Hr.	82·988	159·9	19·42	8–10	
h 3430	St. 517	1 16·5	57 52	Pk.	89·849	238·6	1·86	7–11	
	A G C 1601	1 34·5	45 6	Pk.	87·897	37·8	1·08	8–8·2	
				Pk.	87·934	37·8	0·97		
				Pk.	89·849	38·3	1·25		
	A G C 1606	1 34·9	53 57	Pk.	87·895	103·7	10·33	7–7·5	
				Pk.	87·925	104·4	10·31		
p Eridani h 3453	St. 667	1 36·0	56 42	Pk.	86·901	229·9	6·63	6–6	
	...	..		Pk.	86·909	230·8	6·85		
				Pk.	87·893	228·4	6·44		
				Pk.	87·895	228·0	6·36		
				Pk.	87·915	229·5	...		
				Pk.	87·928	229·1	6·47		
				Pk.	89·813	227·9	7·04		
				Pk.	89·849	228·6	7·10		
				Pk.	90·003	226·5	...		
				Pk.	90·019	227·4	7·03		
				Pk.	90·022	227·9	7·01		
	A G C 1636	1 36·2	45 33	Pk.	89·890	144·9	6·53	8·5–10	
Santiago 14	St. 693	1 39·3	82 47	Pk.	87·945	52·9	6·08	6·5–8	
				Pk.	87·947	53·0	5·97		
	A G C 1908	1 52·1	60 48	Hr.	82·033	35·9	2·04	8–8	
	A G C 1941	1 53·8	52 41	Pk.	87·925	41·5	3·94	8·5–10	
				Pk.	87·928	39·9	3·98		
h 3477	...	1 55	45 0	Hr.	82·986	157·6	9·09	10–10	
h 3483	A G C 2126	2 2·3	71 44	Hr.	82·986	296·3	7·11	10–10	
h 3494	St. 928	2 15·6	35 54	Pk.	87·936	75·6	1·42	7·5–7·5	
h 3536	St. 1162	2 46·2	36 15	Pk.	88·041	12·6	6 est.	6–12	
h 3541	...	2 49	60 17	Hr.	83·027	157·0	2·19	8–10	
h 3542	A G C 3165	2 51·6	64 49	Hr.	83·027	143·3	11·70	10–10	
θ Eridani h 3545½	St. 1230	2 54·5	40 42	Pk.	88·041	84·0	7·91	3·5–5·5	
				Pk.	88·047	84·5	7·85		
				Pk.	89·890	83·4	8·48		
				Pk.	90·019	85·1	8·32		
				Pk.	90·C22	84·4	8·23		

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
h 3553	A G C 3415	3 5·6	38 14	Hr.	83·041	225·3	11·23	9–10	
12 Eridani	St. 1317	3 7·8	29 23	Pk.	87·997	318·7	1·27	4–7	
				R.	88·003	321·3	1·79		
h 3589	St. 1567	3 40·6	40 58	Hr.	83·038	349·0	4·64	7–11	
h 3592	St. 1586	3 42·0	54 36	Pk.	87·950	10·2	4·80	6·5–10	
				Pk.	87·997	11·3	5·13		
				Pk.	90·019	11·0	5·32		
				Pk.	90·022	12·0	5·22		
	A G C 4409	3 53·1	40 11	Pk.	88·041	141·0	4·03	7–7·5	
				Pk.	88·047	142·6	4·27		
h 3645	...	4 17	44 36	Hr.	83·115	138·9	7·87	10–10	
h 3713	...	4 55	43 18	Hr.	83·153	343·6	23·19	10–11	
h 3715	St. 2192	4 56·9	49 36	Hr.	82·186	109·5	8·80	8-9	
h 3722	...	4 57	74 24	Hr.	83·123	156·4	24·49	10–10	
h 3724	...	5 0	56 8	Hr.	83·142	285·3	2·49	10–10	
h 3725	A G C 5884	5 3·7	39 46	Hr.	83·118	144·8	22·30	9–9	
h 3729	...	5 4	45 9	Hr.	83·142	232·3	8·55	10–10	
h 3731	...	5 5	55 42	Hr.	83·118	306·5	7·82	9–11	
h 3747	...	5 13	67 56	Hr.	83·173	110·5	7·19	9–11	
h 3744	...	5 13	38 16	Hr.	83·173	286·2	4·10	10–11	
h 3754	...	5 15	70 1	Hr.	82·186	130·1	17·15	10–11	
h 3753	...	5 17	35 45	Hr.	82·186	177·3	19·96	9–10	
h 3768	...	5 28	66 36	Hr.	83·173	16·9	2·30	11–11	
h 3781	A G C 6617	5 35·4	41 21	Hr.	83·175	134·8	15·36	9–11	
h 3787	St. 2551	5 35·8	54 37	Hr.	82·200	249·0	13·00	8–10	
h 3817	...	5 43	80 24	Hr.	83·123	236·9	22·13	9–10	
h 3810	St. 2654	5 47·0	61 14	Hr.	83·175	168·0	21·78	9–11	
h 3815	...	5 48	65 48	Hr.	82·200	147·8	24·88	10–11	
h 3835½	St. 2795	6 2·2	48 27	Pk.	88·082	20·3	1·56	7·5–7·5	
				Pk.	88·101	19·2	1·76	8–8·2	
				Pk.	90·019	26·4	1·61	7–7·5	
h 3838	...	6 4	65 19	Hr.	83·162	311·4	8·16	11–11	
h 3857	St. 2971	6 20·5	36 39	Hr.	82·225	254·9	12·24	7–12	
h 3851	...	6 20	61 1	Hr.	83·153	63·4	11·51	10–11	
		6 25	75 23	Hr.	83·194	54·7	2·93	9–11	
β 755	St. 3091	6 31·9	36 42	Pk.	87·227	252·3	0·88	6–7	A and B
				Pk.	87·246	253·0	0·67	...	
				Pk.	87·247	253·9	...	...	
				Pk.	87·246	301·0	21·22	6–11	A and C
h 3882	...	6 36	44 54	Hr.	82·219	328·7	18·06	10–11	
h 3883	...	6 36	44 54	Hr.	82·219	66·0	6·72	10–11	
h 3886	...	6 37	62 6	Hr.	83·162	220·6	28·19	9–10	A 3rd star s.f. 11m.

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
h 3900	A G C 8648	6 50·6	34 6	Pk.	87·249	281·0	2·26	8–10	
h 3926	...	6 54	76 54	Hr.	83·200	295·4	23·71	10–10	
h 3932	St. 3402	6 58·8	77 39	Hr.	82·233	282·6	7·50	8–10	
	St. 3418	7 1·7	59 2	Hr.	83·274	78·4	1·86	8–9	
h 3937	...	7 6	60 47	Hr.	83·200	28·5	4·88	10–10	
	St. 3480	7 7·8	60 25	Hr.	83·290	304·9	1·01	8–8	
h 3941	St. 3485	7 8·0	60 13	Pk.	88·082	301·0	0·8 est.	7–8·3	
h 3944	...	7 8	62 54	Hr.	83·249	285·4	16·15	9–11	
β 757	St. 3489	7 8·9	36 23	Pk.	87·227	67·7	2·57	6·5–8	
π Argus *h* 3946½	A G C 9288	7 13·6	36 55	Hr.	82·137	212·7	57·38	3–8	
h 3957	...	7 16	36 0	Hr.	83·249	193·8	7·05	6–7	
h 3958	A G C 9434	7 18·2	52 1	Hr.	83·309	18·2	9·45	7–7	
h 3962	A G C 9461	7 18·8	56 42	Hr.	82·085	106·9	8·32	8–9	
h 3981	...	7 29	48 56	Hr.	83·233	327·5	14·82	9–10	
h 3986	...	7 31	50 40	Hr.	83·271	219·6	42·65	9–10	
h 3989	...	7 32	60 58	Hr.	83·233	227·5	16·17	10–11	
h 3990	A G C 9921	7 35·5	47 29	Hr.	83·233	341·6	37·27	8–9	
h 4031	A G C 10595	7 56·7	60 35	Pk.	87·296	358·1	5·51	8–9	
	M C 1–399	8 3·3	60 6	Pk.	87·227	347·6	1·46	8–9	
h 4097	...	8 21	60 37	Hr.	82·331	3·0	10·28	10–11	
h 4128	St. 4523	8 34·6	59 59	Hr.	82·331	215·2	1·28	8–8	
		8 39	61 50	Hr.	83·334	350·6	10·88	10–10	
		8 48	62 47	Hr.	83·413	49·7	7·93	11–11	
		8 48	58 5	Hr.	83·334	272·1	1·67	9–10	
h 4165	St. 4816	8 58·6	51 48	Pk.	87·326	96·5	0·88	7–8	
h 4194	...	9 4	83 12	Hr.	82·348	52·8	12·11	10–10	
h 4196	...	9 13	51 22	Hr.	82·353	119·1	2·73	10–11	
h 4208	...	9 21	36 48	Hr.	82·348	130·2	15·23	9–10	
h 4215	...	9 24	49 2	Hr.	82·372	259·7	9·25	10–11	
h 4220	St. 5161	9 30·2	48 34	Hr.	82·372	204·1	1·57	6–6·5	
	St. 5196	9 32·8	48 18	Hr.	82·372	170·0	3·06	7–11	
h 4229	...	9 35	38 24	Hr.	82·359	331·0	7·24	11–11	
h 4234	...	9 36	51 46	Hr.	82·356	215·5	19·68	9–11	
h 4240	...	9 40	59 30	Hr.	82·359	57·6	12·15	9–10	
h 4242	...	9 41	41 10	Hr.	82·348	358·8	7·48	8–10	
h 4247	...	9 43	51 28	Hr.	82·353	83·1	5·40	9–10	
h 4250	...	9 45	36 25	Hr.	82·359	67·0	8·75	10–10	
		9 46	62 38	Hr.	83·403	117·1	4·23	9–11	
		9 59	61 32	Hr.	83·372	351·2	0·63	9–10	
h 4308	...	10 14	71 27	Hr.	82·367	57·7	15·97	9–9	
T Velorum *h* 4310½	St. 5655	10 17·2	55 32	Pk.	87·227	102·9	6·97	5–9	A and B

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		h m	° ′			°	″		
T Velorum	St. 5655	10 17·2	55 32	Pk.	87·227	189·6	36·84	5–9	A and C
h 4315	A G C 14206	10 20·0	43 32	Hr.	82·370	207·8	23·30	9–10	
Syd. 1–149	...	10 25	66 28	Hr.	83·334	137·0	3·21	9–10	
h 4330	St. 5781	10 28·7	46 29	Hr.	82·386	163·2	40·05	5–10	
h 4332	St. 5788	10 29·1	46 26	Hr.	82·386	164·1	28·11	7–11	
h 4334	...	10 30	34 51	Hr.	82·386	265·7	6·41	10–11	
μ Argus	St. 5957	10 42·5	48 54	Pk.	89·329	56·5	2·50	4–8	
				Pk.	89·334	56·3	2·60		
				Pk.	89·370	60·3	2·35		
h 4373	...	10 43	40 54	Hr.	82·329	339·1	10·44	9–10	
		10 48	58 17	Hr.	83·372	216·8	4·06	9–11	
		10 48	72 18	Hr.	83·403	282·3	1·52	10–10	
		11 1	60 26	Hr.	83·403	162·5	5·48	10–10	
η Carinæ	St. 6223	11 8·3	59 46	Pk.	89·331	275·0	21·42	5–11	
h 4414				Pk.	89·342	275·6	21·96		
	A G C 15437	11 11·8	45 20	Pk.	89·307	275·4	2·03	7·5–7·5	
				Pk.	89·329	274·6	2·29		
		11 14	59 0	Hr.	83·427	150·2	4·94	9–11	
h 4433½	...	11 15	61 0	Hr.	83·422	337·9	2·41	9–10	
		11 17	59 8	Hr.	83·403	255·4	6·48	10–11	
		11 18	58 43	Hr.	83·422	56·0	3·53	9–11	
h 4432	St. 6341	11 19·0	64 24	Pk.	89·334	297·9	2·43	6–8	
				Pk.	89·345	298·6	2·27		
				Pk.	89·345	295·9			
				Pk.	89·370	293·8	2·33		
		11 19	61 5	Hr.	83·422	7·7	6·85	10–11	
		11 23	61 5	Hr.	83·427	145·7	5·98	10–11	
		11 23	63 6	Hr.	83·433	260·7	5·24	10–10	
		11 24	62 56	Hr.	82·394	261·5	4·73	11–11	
h 4446	...	11 27	51 52	Hr.	82·394	118·5	10·02	10–10	
h 4447	...	11 27	63 20	Hr.	82·394	348·8	18·87	11–11	
h 4452	...	11 28	63 19	Hr.	82·394	323·8	16·06	10–11	
		11 30	59 47	Hr.	83·433	77·0	9·69	10–11	
		11 31	60 25	Hr.	83·433	4·3	1·67	9–10	
	St. 6516	11 35·9	62 1	Pk.	87·323	221·3	2·66	7–7·5	
				Pk.	87·361	219·3			
				Pk.	89·307	219·0	3·12		
				Pk.	89·329	219·3	2·65		
h 4475	...	11 43	60 59	Hr.	82·465	326·7	5·14	10–11	
Santiago 169	St. 6619	11 46·9	64 2	Pk.	87·370	230·7	2·81	8–9·5	
				Pk.	87·504	231·7			
Washburn 114	St. 6641	11 49·9	55 32	Pk.	87·370	205·0	0·52	7–8	

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
Washburn 114	St. 6641	11 49·9	55 32	Pk.	87·394	208·0	1·81		
				Pk.	87·476	206·9	1·83		
	St. 6777	12 4·9	34 9	Pk.	87·430	19·5	2·99	6·5–9·5	
				Pk.	87·460	22·2	3·16		
Syd. 1–191	...	12 5	60 25	Pk.	89·331	211·3	3·18	8–9	
				Pk.	89·334	214·0	3·30		
h 4507	...	12 7	44 21	Hr.	82·465	222·5	16·35	8–9	Another star measured for this 79·424
				Pk.	87·449	223·8	16·62		
h 4515	...	12 14	69 13	Hr.	82·471	55·2	11·64	9–11	
h 4516	...	12 18	63 24	Hr.	82·471	98·8	14·56	9–11	
h 4518	A G C 16915	12 19·4	40 50	Pk.	89·285	207·4	9·93	6·5–9	
				Pk.	89·331	207·6	10·58		
h 4523	...	12 21	57 1	Hr.	82·471	274·4	6·05	11–11	
Syd. 1–201	St. 6923	12 22·7	61 12	Pk.	87·370	269·3	0·79	7·5–8·5	
				Pk.	87·476	268·0	1·65		
h 4531	...	12 30	51 33	Hr.	82·482	20·7	15·56	9–10	
Washburn 116	St. 7001	12 32·5	55 23	Pk.	89·329	194·5	1·77	7·5–9	
				Pk.	89·334	192·3	2·11		
				Pk.	89·370	192·6	2·13		
					89·370	193·1			
γ Centauri	St. 7022	12 36·0	48 25	Pk.	87·446	357·6	2·38	3–3	
				Pk.	87·498	358·7	1·79		
				Pk.	87·512	360·1	1·31		
				Pk.	87·531	360·2			
				Pk.	87·572	356·8	1·76		
				Pk.	87·600	357·5	1·52		
				Pk.	89·285	359·3	1·63		
				Pk.	89·329	357·9	1·60		
				Pk.	89·334	359·4	2·04		
				Pk.	89·345	359·8	1·67		
h 4538	...	12 37	83 4	Hr.	82·482	281·0	3·25	10–11	
h 4546	St. 7047	12 39·2	52 13	Hr.	82·490	222·7	14·44	8–10	
h 4547	St. 7049	12 39·7	60 26	Hr.	82·482	37·6	23·34	6–11	
β Muscæ } Syd. 1–207 }	St. 7053	12 40·1	67 34	R.	86·501	322·0	0·79	4–4	
				Pk.	86·594	325·8	0·5 est.		
				R.	86·597	323·7	0·5 est.		
				Pk.	87·512	328·1	0·88		
				Pk.	87·515	327·0			
				Pk.	87·531	326·7	0·74		
				Pk.	87·550	327·4			

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes	
		h m	° ′			°	″		
β Mus. Syd. 1–207	St. 7053	12 40·1	67 34	Pk.	87·572	326·7			
				Pk.	87·586	325·0			
				Pk.	87·600	326·7	1·06		
h 4552	...	12 45	46 20	Hr.	82·504	313·6	27·51	9–10	
	A G C 17639	12 52·8	70 6	Pk.	89·307	268·6	4·28	8·5–10	
				Pk.	89·329	269·1	4·30		
				Pk.	89·331	270·4	3·67		
				Pk.	89·334	270·6	4·23		
	A G C 17678	12 54·6	48 4	Pk.	89·430	66·8	5·04	7–10	
				Pk.	89·460	67·8	5·02		
h 4578	A G C 18081	13 12·0	36 29	Pk.	89·460	153·9	8·23	8–10	
				Pk.	89·468	152·6	7·87		
		13 22	43 0	Pk.	89·334	171·3	2·42	8·5–10	
				Pk.	89·345	172·3	2·60		
				Pk.	89·370	168·8	2·16		
Syd. 2–86	...	13 27	61 50	Pk.	89·307	239·7	1·47	9–9	
				Pk.	89·329	237·6	1·67		
h 4600	...	13 32	48 30	Hr.	82·504	118·7	16·40	8–10	
h 4603	...	13 35	50 10	Hr.	82·504	151·8	7·13	10–11	
	A G C 18587	13 35·3	54 3	Pk.	89·329	162·5	5·81	6–7·5	
				Pk.	89·331	163·5	5·58		
h 4609	...	13 38	37 10	Pk.	87·518	149·8	5·67	8–9	
				Pk.	87·537	148·2	6·31		
				Pk.	87·542	149·7	5·58		
		13 41	36 8	Pk.	87·518	90·5	...	8·5–9	
				Pk.	87·537	86·3	7·05		
				Pk.	87·542	84·3	6·72		
h 4626	...	13 48	69 50	Hr.	82·526	55·8	4·01	9–9	
h 4625	...	13 48	42 5	Hr.	82·526	6·8	13·65	9–9·5	
		14 4	46 43	Pk.	87·430	53·2	4·12	8·5–9	
				Pk.	87·460	55·4	4·20		
h 4655	A G C 19209	14 4·7	36 24	Pk.	89·430	268·2	6·01	8·5–10	
				Pk.	89·460	267·9	5·04		
h 4656	...	14 5	51 35	Hr.	82·526	288·0	15·39	9–9·5	
	St. 7766	14 7·7	61 14	Pk.	87·542	161·2	3·37	7–9	
				Pk.	87·548	158·7	2·89		
				Pk.	87·550	158·9	2·69		
	A G C 19385	14 14·6	41 59	Pk.	89·331	210·8	1·79	8–8	
				Pk.	89·334	213·0	1·79		
				Pk.	89·438	210·1	1·90		
h 4675	...	14 18	54 23	Hr.	82·542	335·7	5·42	10–11	
h 4683	...	14 22	61 50	Hr.	82·542	62·5	19·35	10–10	

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
h 4687	...	14 29	36 7	Pk.	89·370	87·6	1·77	8·5–9	
	A G C 19782	14 30·6	37 6	Pk.	89·367	214·6	4·09	8–9	
				Pk.	89·424	214·6	4·50		
α Centauri	St. 7965	14 32·8	60 25	R.	84·194	199·0	11·96	1–...	
				R.	84·433	199·5	12·32	...	Δ α and Δ δ
				Pk.	86·296	202·4	15·69		
				Pk.	86·301	202·9	15·02		
				Pk.	86·320	203·1	15·09		
				Pk.	86·326	202·3	14·73		
				R.	86·378	200·4	14·74		
				Pk.	86·378	201·9	14·84		
				R.	86·520	201·2	15·19		
				Pk.	86·526	201·8	15·33		
				Pk.	86·526	200·7	14·68	...	Δ α and Δ δ
				Pk.	86·534	202·3	14·70		
				Pk.	86·548	200·9	14·82	...	Δ α and Δ δ
				Pk.	86·548	202·6	15·06		
				Pk.	86·550	202·2	15·15		
				Pk.	86·550	201·8	14·78	...	Δ α and Δ δ
				Pk.	86·550	202·7			
				Pk.	86·553	202·7	14·96		
				Pk.	86·567	200·7	15·19	...	Δ α and Δ δ
				Pk.	86·567	203·1	15·25		
				R.	86·570	201·7	15·17	...	Aperture 6-inch, power 320
				R.	86·570	201·8	15·24	...	Aperture 6-inch, power 800
				Pk.	86·570	202·2	15·21		
				Pk.	86·583	202·6	15·00		
				Pk.	86·594	202·5	14·96		
				Pk.	86·602	202·1	15·63		
				R.	86·605	201·6	15·15		
				Pk.	87·323	201·2	16·01		
				Pk.	87·383	202·0	15·15	...	A.M.
				Pk.	87·383	201·9	14·23	...	P.M.
				Pk.	87·419	201·9	...	...	A.M.
				Pk.	87·419	201·0	16·17	...	P.M.
				Pk.	87·422	202·1	...	...	A.M.
				Pk.	87·422	201·4	16·06	...	P.M.
				Pk.	87·455	203·1	16·05	...	A.M.
				Pk.	87·455	202·2	16·19	...	P.M.
				Pk.	87·455	202·8			

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
α Centauri	St. 7965	14 32·8	60 25	Pk.	87·474	203·0			
				Pk.	87·498	202·5	16·46	...	A.M.
				Pk.	87·498	201·9	16·10	...	P.M.
				Pk.	87·726	202·9	15·44	...	P.M.
				Pk.	87·739	202·9	15·79		
				Pk.	87·742	203·4	16·01		
				Pk.	87·745	202·8	15·70		
				Pk.	89·285	204·3	17·60		
				Pk.	89·455	205·5	17·97	...	A.M.
				Pk.	89·455	203·9	18·04	1–3	P.M.
				Pk.	89·616	204·3	18·04		
Santiago 213	St. 8142	14 52·3	67 35	Pk.	87·526	335·0	4·97	7·5–9	
				Pk.	87·537	331·6	5·04		
				Pk.	87·542	331·2	5·18		
π Lupi	St. 8191	14 58·3	46 40	Pk.	86·550	91·1	0·87	4·5–4·5	
				R.	86·570	93·0	0·56		
				Pk.	86·597	89·8	0·8 est.		
				Pk.	87·498	90·1	1·08		
				Pk.	87·531	85·6	1·08		
				Pk.	87·572	88·5	1·56		
				Pk.	87·695	84·6			
h 4734	St. 8236	15 3·8	54 58	Pk.	87·518	244·1	11·67	5·5–11	
				Pk.	87·542	245·5	11·01		
h 4735	A G C 20560	15 4·8	60 1	Pk.	87·542	32·9	6·88	8–11	
				Pk.	87·548	29·9	7·35		
				Pk.	87·550	30·9	7·17		
Washburn 121	A G C 20576	15 5·6	51 39	Pk.	89·479	214·8	2·10	8–9	
				Pk.	89·520	218·1	2·31		
				Pk.	89·622	219·0	2·35		
	A G C 20682	15 10·0	53 52	Pk.	89·479	143·9	3·12	8–9·5	
				Pk.	89·611	143·4	3·01		
h 4755	...	15 12	36 23	Hr.	82·542	201·8	4·32	8–9	
Syd. 2–116	St. 8344	15 15·1	37 51	Pk.	87·449	123·2	5·49	7·5–10	
				Pk.	87·474	124·1	5·50		
h 4776	St. 8421	15 23·7	41 34	Pk.	89·457	229·1	5·92	7·5–9	
				Pk.	89·468	227·5	5·68		
	A G C 21676	15 54·6	40 9	Pk.	89·479	156·3	8·45	6·5–10	
				Pk.	89·520	156·8	8·28		
Syd. 1–275	A G C 22014	16 10·0	64 19	Pk.	87·518	350·6	4·03	8·5–9·5	
				Pk.	87 526	349·8			
				Pk.	87·550	351·0	3·85		

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800 +.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
ι Tri-Aust. Syd. 1–278	St. 8917	16 18·6	63 50	Pk.	86·611	20·5	21·61	5·5–9	
		16 33	47 26	Pk.	89·468	100·2	2·80	8·5–9	
				Pk.	89·613	102·6	2·42		
	St. 9118	16 42·9	49 52	Pk.	89·542	44·6	3·03	8–8	
				Pk.	89·613	43·8	2·71		
Syd. 1–288	...	16 55	48 46	Pk.	87·556	49·9	...	9–9·5	A and B
				Pk.	87·564	49·7	2·92	...	A and B
				Pk.	87·572	50·9	2·76	...	A and B
h 4906	...	...	...	Pk.	87·564	233·9	14·96	9–11	A and C
				Pk.	87·572	235·8	15·62	...	A and C
	St. 9248	16 55·2	50 1	Pk.	87·600	233·9	8·14	7–7·5	
				Pk.	87·602	234·2	8·03		
				Pk.	89·479	234·3			
				Pk.	89·575	234·1	7·80		
				Pk.	89·613	234·1	8·14		
	AGC 23077	16 57·6	47 6	Pk.	89·438	236·0	3·32	8·5–9	
				Pk.	89·468	237·1	3·30		
h 4917	...	17 2	54 12	Pk.	87·687	349·0	12·17	8–11	
				Pk.	87·690	348·2	11·47		
h 4920	St. 9339	17 4·3	58 28	Pk.	86·611	328·3	2·64	8–9	
h 4931	AGC 23399	17 11·8	59 20	Pk.	86·570	254·7	0·7 est.	8–8	
				R.	86·570	259·0	0·7 est.		
h 4938	...	17 11	56 14	Hr.	82·663	110·5	24·27	8–8	
β 416	AGC 23422	17 12·1	34 53	Pk.	89·630	131·9	0·97	6–8·5	
h 4939	...	17 12	56 17	Hr.	82·663	223·1	28·52	8–9	
γ Aræ *h* 4942	St. 9457	17 16·9	56 17	Hr.	82·663	328·5	16·80	3–12	
h 4945	...	17 17	47 46	Hr.	82·657	112·6	5·27	9–10	
h 4949	St. 9488	17 19·5	45 45	Pk.	86·605	262·7	2·34	7–7·5	
h 4950	...	17 20	57 23	Hr.	82·657	309·0	7·31	10–11	
h 4958	...	17 24	40 28	Hr.	82·665	56·0	17·40	10–10	
	St. 9608	17 33·4	53 25	Pk.	87·591	296·0	10·94	7–9	
				Pk.	87·594	296·8	10·70		
Syd. 2–124	...	17 34	52 45	Pk.	87·575	125·5	4·50	8·5–8·5	
				Pk.	87·589	127·8	4·93		
				Pk.	87·591	125·5	5·07		
		17 34	34 58	Pk.	86·613	258·2	4·53	8·5–9	
				Pk.	87·665	256·8	5·06		
				Pk.	87·668	256·7	4·89		
Syd. 1–303	...	17 39	54 5	Pk.	87·575	109·6	3·37	7·5–8·5	
				Pk.	87·591	109·8	3·69		

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
h 4981	...	17 41	50 14	Hr.	82·643	198·2	2·23	10–10	
h 4979	St. 9693	17 43·0	60 22	Pk.	87·662	237·7	10·45	7–9	
				Pk.	87·668	238·1	10·40		
h 4983	...	17 45	66 26	Hr.	82·657	12·8	21 88	9–10	
h 4996	A G C 24351	17 51·3	62 10	Pk.	87·685	248·5	...	8–10	
				Pk.	87·687	248·6	6·08		
				Pk.	87·737	249·1			
h 5003	St. 9795	17 52·7	30 15	Hr.	82·663	105·1	4·79	6–7	
h 5007	A G C 24514	17 56·6	37 15	Hr.	82·701	217·4	9·88	9–10	
h 5011	St. 9847	17 59·3	41 46	Hr.	82·701	351·3	29·65	8–9	
h 5014	St. 9853	17 59·6	43 26	Pk.	86·572	74·8	1·27	7–7	
				Pk.	87·742	73·5	1·11		
				Pk.	87·756	72·4	1·65		
				Pk.	87·764	73·1			
h 5027	...	18 5	54 23	Hr.	82·643	96·3	12·28	8·5–9·5	
				Pk.	86·597	95·2	12·90		
				Pk.	89·633	98·5	12·26		
				Pk.	89·687	98·5	12·17		
				Pk.	89·690	98·5	12·39		
β 759	A G C 24739	18 5·2	39 22	Pk.	86 605	121·7	2·17	8·5–9	A and B
				Pk.	87·695	122·1	2·51	...	
				Pk.	87·706	122·2	1·72	...	
h 5028	...	...	...	Pk.	86·605	148·7	15·27	8·5–9	A and C
h 5031	...	18 6	47 21	Hr.	82 704	87·0	23·35	9–9·5	
h 5034	...	18 8	46 6	Hr.	82·704	102·1	2·37	9–10	
η Sagittarii *β* 760	St. 9962	18 0·9	36 48	Pk.	86·712	99·5	4·36	4–11	
h 5039	...	18 14	66 9	Hr.	82·704	130·3	16·60	10–11	
	A G C 25017	18 16·1	42 49	Pk.	89·520	137·3	3·75	8·5–8·5	
				Pk.	89·575	136·8	3·48		
h 5041	St. 10013	18 17·7	53 42	Pk.	86·597	258·9	2·64	7–8·5	
				Pk.	89·633	259·5	2·51		
				Pk.	89·649	260·4	2·46		
				Pk.	89 674	261·3	2·69		
				Pk.	89·690	261·0	2·55		
		18 19	36 48	Pk.	86·709	228·7	3·33	8–9·5	
				Pk.	87·687	225·7	3·78		
				Pk.	87·690	224·8	3·37		
Syd. 1–309	St. 10159	18 34·3	55 59	Pk.	86·613	218·7	3·41	8–8·5	
Syd. 1–317	A G C 26016	18 55·7	45 52	Pk.	86·597	275·3	1·80	8–8·5	A and B
				Pk.	89·630	278·9	1·47	...	
h 5078	...	...	...	Pk.	86 597	212·3	18·88	8·5–9	A and C

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800+.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
h 5079	...	18 56	48 20	Hr.	82·715	237·5	15·69	9–10	
ζ Sagittarii	St. 10349	18 56·3	30 1	Pk.	86·739	271·1			
				Pk.	87·531	261·6			
				Pk.	87·572	268·5			
				Pk.	87·695	263·6			
				Pk.	87·706	262·9			
				Pk.	87·745	264·1			
	A G C 26036	18 56·3	42 25	Pk.	86·742	0·5	2·01	9–9	
				Pk.	89·613	0·8	2·17		
				Pk.	89·630	1·4	2·21		
h 5074	...	18 56	78 44	Hr.	82·715	347·3	22·29	9–10	
h 5081	...	18 56	53 53	Hr.	82·715	175·2	16·10	10–11	
γ Coronæ Aust.	St. 10373	18 59·6	37 12	Pk.	86·567	199·6	1·70	6–6	
				Pk.	86·570	200·5	1·40		
				Pk.	86·572	199·9	1·11		
				Pk.	86·591	200·5	1·35		
				Pk.	86·597	200·9	1·06		
				Pk.	86·613	200·6	1·64		
				R.	86·704	203·5	1·52		
				Pk.	86·704	201·3	1·74		
				Pk.	86·706	201·4	1·63		
				Pk.	87·570	196·7	1·51		
				Pk.	87·706	197·5	0·86		
				Pk.	87·737	196·4	1·17		
				Pk.	87·745	196·0	1·11		
h 5085	...	19 2	60 12	Pk.	86·550	241·0	3·14	8·5–9	
				Pk.	86·567	240·8	2·97		
β 761	...	19 32	40 1	Pk.	86·712	198·7	2·55	7–11	
	St. 10607	19 34·4	53 11	Pk.	86·810	54·9	3·54	7–8	
				Pk.	87·690	46·5	3·44		
				Pk.	87·695	47 8	3·48		
				Pk.	87·706	51·1			
				Pk.	87·717	49·2			
β 762	St. 10844	20 10·6	32 55	Pk.	87·695	303·9	2·80	8–8	
				Pk.	87·717	305 0	2·76		
				Pk.	87·723	303·1			
				Pk.	87·737	303·3			
	St. 10850	20 11·1	40 30	Pk.	87·791	114·0	9·32	7–7	
				Pk.	87·797	114·1	9·54		
β 763	St. 10893	20 17·1	42 45	Pk.	86·605	211·0	0·7 est.	7–8	
				Pk.	87·745	213·2	0·93		

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800 +.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
β 763	St. 10893	20 17·1	42 45	Pk.	87·786	215·7			
Santiago 259	St. 10941	20 25·2	41 14	Pk.	86·805	156·1	...	8–8	
				Pk.	87·780	153·2	2·71		
				Pk.	87·780	151·2			
				Pk.	87·797	152·3			
				Pk.	89·633	151·8	3·12		
				Pk.	89·690	153·4	3·28		
				Pk.	89·734	152·2	3·28		
	St. 10955	20 27·1	40 54	Pk.	87·737	225·4	3·96	7–7·5	
				Pk.	87·742	224·8	4·23		
h 5228	St. 11081	20 45·1	41 26	Hr.	81·819	104·6	31·38	8–10	
h 5235	St. 11178	21 0·6	84 43	Pk.	86·605	262·4	3·39	8–8	
h 5246	St. 11225	21 3·1	54 59	Pk.	86·602	125·7	3·74	8–8	
				Pk.	89·734	123·3	3·16		
				Pk.	89·737	124·0	3·23		
				Pk.	89·767	123·4	3·12		
θ Indi *h* 5258	St. 11299	21 12·7	53 52	Pk.	86·602	286·9	4·56	5–8	
θ_2 Micros. β 766	St. 11337	21 18·0	41 26	Pk.	86·706	302·0	0·5 est.	6–7	
β 767	St. 11359	21 20·6	42 59	Pk.	86·602	146·3	3·47	6–8	
				Pk.	87·690	142·0	3·28		
				Pk.	87·695	144·2	3·37		
				Pk.	87·723	143·1	2·78		
h 5261	St. 11378	21 28·6	86 18	Pk.	86·602	24·0	5·33	7·5–7·5	
				Pk.	87·726	22·0	5·49		
				Pk.	87·742	23·1	5·36		
				Pk.	87·767	22·7	5·59		
λ Octantis *h* 5278	St. 11435	21 35·6	83 11	R.	86·797	77·7	3·30	8·5–9	
h 5294	...	21 36	60 38	Hr.	81·819	191·6	7·43	10–10	
h 5295⅔	St. 11486	21 41·7	47 45	Pk.	86·605	2·0	42·35	5·6–8	
				Pk.	89·657	1·1	43·30		
				Pk.	89·731	1·5			
				Pk.	89·737	1·4	43·57		
				Pk.	89·767	1·5	43·19		
	A G C 30333	22 6·1	38 48	Pk.	89·813	119·0	1·86	8–8	
				Pk.	89·821	118·8	2·17		
	A G C 30340	22 6·7	49 33	Pk.	89·849	355·5	5·29	8–10	
				Pk.	89·884	351·6	4·73		
				Pk.	89·887	352·6	4·54		
		22 11	79 0	R.	86·802	307·3	5·15	9·5–9·5	One of 5 stars making a crown
	St. 11690	22 13·9	79 43	Pk.	86·802	307·3	5·15	8–8	

Name.	No. in Star Catalogue.	R.A. 1900.	S. Dec. 1900.	Obs.	Epoch 1800 +.	Pos. Angle.	Dist.	Magnitudes.	
		h m	° ′			°	″		
h 5344	St. 11798	22 29·8	39 15	Pk.	89·786	167·3	5·25	8–10	
				Pk.	89·810	167·1	5·15		
h 5368	...	22 50	85 7	R.	86·802	123·3	8·12	9–9·5	
β 1011	St. 11983	22 57·0	36 57	Pk.	86·915	301·2	2·26	7–10	
	A G C 31333	22 58·3	46 42	Pk.	89·813	106·8	3·21	8–10	
				Pk.	89·821	110·0	2·99		
				Pk.	89·849	109·0	2·96		
β 775	St. 12213	23 31·8	32 25	Pk.	86·904	245·5	5·34	7–9·5	
				Pk.	86·939	250·5	5·86		
Syd. 1–348	...	23 34	69 41	Pk.	89·786	348·8	4·95	8–9	
				Pk.	89·789	348·4	4·93		
θ Phœnicis *h* 5411½	St. 12228	23 34·1	47 12	Pk.	87·745	270·9	4·43	6·5–7	
				Pk.	87·830	269·2	4·18		
Santiago 289	...	23 54	67 27	Pk.	89·786	263·3	3·64	8–10	
				Pk.	89·789	262·1	3·66		
	A G C 32408	23 58·8	48 41	Pk.	87·780	69·2	...	8·5–10	
				Pk.	87·871	68·8	2·40		
				Pk.	87·893	66·0	2·89		

Double-Star Observations, 1888–91. By W. H. Maw.

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The observations recorded in the present paper have been made with a 6-inch equatorial refractor constructed by Messrs. T. Cooke & Sons, of York, and fitted with a double parallel wire micrometer by the same makers. The micrometer is provided with five eye-pieces having magnifying powers as follows:—

I. = 90.
II. = 130.
III. = 215.
IV. = 300.
V. = 400.

The value of the micrometer screw, as determined by measurements of distances apart of stars in the Pleiades, and by transits of β *Ursæ Minoris* and other stars is $23''\cdot51$ per revolution.

In some cases the micrometer has been used in conjunction with a Barlow lens, and with very satisfactory results. When so used the value of one revolution of the micrometer screw is $11''\cdot93$, and the magnifying powers of the eye-pieces are practically doubled. In the following list of measures the use of the Barlow lens is indicated by the addition of the letter *b* to the number of the eye-piece, thus: I*b*, II*b*, &c.

A night's set of measures of any given pair consisted, as a rule, of four measures of position and three double measures of distance; in many cases, however, these numbers of measures have been exceeded.

In making the measures of angle it has been the invariable rule to occupy such a position that the line joining the centres of the star discs was either parallel with, or perpendicular to, the line joining the eyes of the observer. From time to time when opportunities occurred pairs have been measured in both the positions above-named, with a view of ascertaining the amount of systematic error, if any, due to position. No such systematic error has been discovered; but it has been found that in the case of very unequal pairs the measures of a series differ more *inter se* when the line joining the centre of the star discs is parallel with that joining the eyes of the observer, than they do when the lines joining the centres of the eyes and the centres of the star discs respectively, are perpendicular to each other. With fairly equal stars no effect of this kind has been observed.

The great majority of the pairs recorded in the subjoined list have been measured on at least three nights; but it has been thought desirable to include in the list some easy pairs which have been measured on a less number of nights.

It may be noticed that the list includes few pairs having south declination, this being due to the fact that the position of the author's observatory—situated as it is in London—is such that it is but rarely that stars of low altitude can be effectively measured. The position of the observatory on the western side of London has also led to the majority of the measures being made when the stars measured were to the west of the meridian, the definition towards the south-west portion of the sky being as a rule noticeably better than towards the south-east.

The positions of the stars given in the list are for 1890 and are approximate, the R.A.'s being given to the nearest tenth of a minute of time, and the Dec. to the nearest minute of arc. Of the six columns in which the results are tabulated the first gives the epoch; the second the position-angle; the third the distance; the fourth denotes the eye-piece used; the fifth gives the sidereal time at which the measures were made; and the sixth, remarks.

The measures are as follows:—

(1) Σ 60 = *η Cassiopeæ* (4—7·5)

R.A. 0^h $42.^m3$. Dec. + 57° 14′.

	°	″		h m	
1888·250	184·6	4·98	III.	8 10	
1888·256	184·7	4·76	III.	7 45	
1888·693	181·6	4·86	IV.	19 45	Flaring.
1888·727	182·9	4·89	III.	18 45	
1888·801	183·8	4·67	III.	20 0	
1888·545	183·9	4·83			
1891·737	190·4	4·82	IV.	20 45	
1891·740	190·5	4·75	V.	21 30	
1891·751	194·5	4·79	V.	22 20	
1891·754	191·8	...	V.	19 45	
1891·745	191·8	4·79			

(2) Σ 73 = 36 *Andromedæ* (6·3—6·3)

R.A. 0^h $48.^m9$. Dec. + 23° 2′.

	°	″		h m
1891·067	9·47	1·30	IV.	2 10
1891·080	8·8	1·35	V.	3 35
1891·086	9·3	1·40	V.	2 55
1891·078	9·19	1·35		

The orbit of this pair has recently been made the subject of an interesting paper* by Mr. T. Lewis, F.R.A.S., in which the existing observations since 1830 are fully examined. As a result Mr. Lewis deduces a period of 137·5 years.

(3) Σ 93 = *a Ursæ Minoris* (*Polaris*) (2·5—9·5)

R.A. 1^h $18.^m2$. Dec. + 88° 43′.

	°	″		h m
1889·387	213·9	18·17	I.	13 50

* *Vide* the *Monthly Notices of the Royal Astronomical Society*, vol. li. p. 462.

(4) Σ 138 = P. I. 123 (7—7)

R.A. 1^h $30.^m3$. Dec. +7° 5′.

	°	″		h m
1891·067	217·2	1·52	IV.	3 50
1891·083	215·7	1·41	V.	3 20
1891·086	215·5	1·65	IV.	2 35
1891·079	216·1	1·53		

(5) Σ 174 = P. I. 179 (6·2—7·4)

R.A. 1^h $44.^m1$. Dec. +21° 44′.

	°	″		h m
1889·913	169·4	3·05	IV.	3 55
1890·077	169·2	2·84	IV.	6 10
1890·779	167·7	2·52	IV.	23 15
1890·833	167·6	2·72	IV.	0 50
1890·400	168·5	2·78		

(6) Σ 175 (8·2—8·5)

R.A. 1^h $44.^m9$. Dec. 20° 34′.

	°	″		h m
1887·957	345·16	15·42	III.	3 10

(7) Σ 202 = *a Piscium* (2·8—3·9)

R.A. 1^h $56.^m4$. Dec. +2° 14′.

	°	″		h m
1889·863	320·9	3·09	IV.	3 5
1889·899	321·3	2·96	IV.	2 35
1889·902	321·9	2·99	IV.	3 5
1889·888	321·4	3·01		

(8) Σ 222 = 59 *Andromedæ* (6·7—7·2)

R.A. 2^h $4.^m2$ Dec. +38° 31′.

	°	″		h m
1890·113	35·2	16·46	III.	8 5

(9) Σ 333 = ε *Arietis* (5·7—6)

R.A. 2^h $52.^m9$. Dec. +20° 54′.

	°	″		h m
1890·833	200·2	1·32	V.	1 20
1891·064	203·6	1·32	IV.	7 5
1891·067	200·4	1·31	V.	5 5
1890·988	201·4	1·32		

(10) Σ 470 = 32 *Eridani* (4—6)

R.A. 3^h $48.^m8$. Dec. $-3°$ 17′.

	°	″		h m
1889·108	346·5	6·83	III.	6 55
1889·124	347·4	6·38	III.	6 50
1889·116	346·9	6·60		

Probably fixed.

(11) OΣ 90 (7—9)

R.A. 4^h $48.^m5$. Dec. $+8°$ 25′.

	°	″		h m
1888·976	345·15	1·83	IV.	5 50

There appear to be few published measures of this pair. The following afford no evidence of movement:—

	°	″		
1845·50	343·9	2·06	OΣ.	2 nights.
1866·98	345·6	1·85	De.	4 nights.

(12) OΣ 98 = 14 (*i*) *Orionis* (6—7)

R.A. 5^h $1.^m9$. Dec. $+8°$ 21′.

	°	″		h m	
1889·899	188·8	1·21	IV.	3 15	Unsteady.
1889·943	188·3	0·99	V.	3 30	
1890·034	191·0	1·03	III*b*.	6 15	
1889·920	189·4	1·08			
1891·217	193·8	1·32	IV.	9 20	Distance too great.
1891·220	191·1	1·12	IV.	8 5	
1891·218	192·4	1·22			

(13) Σ 653 = 14 *Aurigæ* (5—7·2)

R.A. 5^h $8.^m2$. Dec. $+32°$ 34′.

	°	″		h m
1889·127	226·5	14·68	III.	9 45
1889·190	225·5	14·64	II.	8 40
1889·158	226·0	14·66		

Probably fixed.

(14) Σ 668 = β *Orionis* (*Rigel*) (1—9)

R.A. 5^h $9.^m3$. Dec. $-8°$ 20′.

	°	″		h m
1890·200	201·3	9·3	III.	6 20
1890·239	201·5	...	III.	7 40
1890·219	201·4	9·3		

(15) Σ 716 = 118 *Tauri* (5·8—6·6)

R.A. 5^h $22.^m5$. Dec. $+25°$ 4′.

	°	″		h m
1889·127	201·6	5·19	III.	8 20
1889·190	201·1	5·09	III.	9 10
1889·158	201·35	5·14		

(16) Σ 774 = ζ *Orionis* (2—5·7—10)

R.A. 5^h $35.^m2$. Dec. $-2°$ 0′.

A—B.

	°	″		h m
1889·226	158·7	2·75	IV.	7 30
1889·228	158·9	2·70	IV.	8 15
1889·234	157·2	2·66	IV.	8 55
1889·229	158·3	2·70		

A—C.

	°	″		h m
1889·228	9·1	56·74	III.	8 30

(17) Σ 3115 (6·7—7·8)

R.A. 5^h $38.^m0$. Dec. $+62°$ 45′.

	°	″		h m
1889·234	25·0	1·58	IV.	10 50
1889·286	24·3	1·45	IV.	11 40
1889·294	22·7	1·42	IV.	12 10
1889·271	24·0	1·48		

Decided decrease in angle.

(18) Σ 795 = 52 *Orionis* (6·2—6·2)

R.A. 5^h $42.^m1$. Dec. +6° 24′.

	°	″		h m
1890·206	205·5	1·69	IV.	9 10
1890·239	205·0	1·48	IV.	9 10
1890·253	206·9	1·67	V.	9 45
1890·232	205·8	1·61		

(19) Σ 796 = P. V. 225 (8—8·5)

R.A. 5^h $42.^m6$. Dec. +31° 45′.

	°	″		h m
1889·234	63·9	3·57	IV.	11 20
1890·206	62·8	3·63	IV.	9 40
1890·239	63·7	3·76	IV.	9 30
1889·893	63·5	3·65		

(20) So. 503 (7—9—8)

R.A. 5^h $49.^m9$. Dec. +13° 56′.

A—B.

	°	″		h m
1889·127	10·34	4·01	III.	7 50
1889·174	6·9	3·43	III.	8 20
1889·190	8·62	3·53	IV.	7 45
1889·164	8·62	3·66		

A—C.

	°	″		h m
1889·174	335·2	236·67	III.	8 40
1889·190	335·3	236·67	III.	8 5
1889·182	335·25	236·67		

(21) Σ 881 = 4 *Lyncis* (6·4—7·6)

R.A. 6^h $11.^m9$. Dec. +59° 26′.

	°	″		h m
1890·247	101·7	0·83	V.	10 40
1890·253	103·0	0·86	V.	10 40
1890·362	101·3	0·92	V.	13 15
1890·287	102·0	0·87		

Steady increase in angle. For comparison we have the following measures:

1830·28	88°·9	0″·81	Σ.	4 nights.
1847·52	95·6	0·87	OΣ.	14 nights.

(22) Σ 918 = 229 *Aurigæ* (6·7—7·7)

R.A. 6^h $25.^m1$. Dec. +52° 33′.

				h m
1890·239	325°·6	4″·63	III.	10 5
1890·253	325·5	4·30	V.	11 5
1890·362	324·5	4·60	IV.	13 45
1890·284	325·2	4·51		

(23) OΣ 149 (6·5—9)

R.A. 6^h $29.^m0$. Dec. +27° 23′.

				h m
1891·217	277°·2	1″·12	IV.	9 45
1891·220	277·7	...	IV.	8 35
1891·218	277·45	1·12		

Rapid retrograde movement, and during recent years a considerable increase in distance. The following are the only published measures which have been found for comparison:

1848·23	350°·73	0″·53	OΣ	3 nights
1868·33	316·57	...	De	3 "
1877·263	303·66	0·73	Sch.	2 "
1882·213	296·50	0·83	Sch.	2 "
1884·180	296·55	0·52	Per.	2 "

(24) Σ 948 = 12 *Lyncis* (5·2—6·1—7·4)

R.A. 6^h $36.^m5$. Dec. +59° 33′.

A—B.

				h m
1889·302	126°·4	1″·62	IV.	12 45
1889·305	124·3	1·52	IV.	11 15
1889·321	123·9	1·56	IV.	13 15
1889·309	124·9	1·57		

A—C.

	°	″		h m
1889·302	305·7	8·41	IV.	13 0
1889·305	304·7	8·41	IV.	11 30
1889·321	305·5	8·41	IV.	13 30
1889·309	305·3	8·41		

(25) OΣ 159 = 15 *Lyncis* (5·1—6·2)

R.A. 6h 47.m8. Dec. +58° 34′.

	°	″		h m
1890·247	1·8	0·76	V.	11 15
1890·253	10·0	0·78	V.	11 30
1890·250	5·9	0·77		

(26) Σ 982 = 38 *Geminorum* (5·4—7·7)

R.A. 6h 48.m4. Dec. +13° 19′.

	°	″		h m
1890·239	161·1	6·39	III.	10 30
1890·253	162·1	6·16	V.	10 15
1890·277	162·8	6·43	III.	10 25
1890·256	162·0	6·33		

(27) OΣ 170 = P. VII. 52 (7·5—7·5)

R.A. 7h 12.m1. Dec. +9° 30′.

	°	″		h m
1891·214	111·3	1·64	IV.	10 35
1891·217	110·5	1·67	IV.	10 20
1891·216	110·9	1·65		

(28) Σ 1066 = δ *Geminorum* (3·2—8·2)

R.A. 7h 13.m6. Dec. +22° 11′.

	°	″		h m
1889·220	205·0	6·58	III.	10 30
1889·228	204·4	6·94	III.	9 15
1889·234	205·3	6·91	IV.	9 15
1889·227	204·9	6·81		

A certain, but extremely slow, increase of angle, and probably a slight reduction of distance.

(29) Σ 1110 = *Castor* (3—3·5—11)

R.A. 7^h $27.^m6$. Dec. +32° 8′.

A—B.

	°	″		h m	
1888·420	230·2	5·87	III.	12 45	
1888·435	229·9	...	II.	13 40	Bad seeing.
1889·220	230·8	5·26	III.	11 0	Indiff. seeing.
1889·228	230·9	5·71	III.	9 45	
1889·286	228·9	6·01	IV.	12 15	
1888·918	230·1	5·71			

A—C.

	°	″		h m
1889·228	163·8	72·46	III.	10 0
1889·286	164·0	72·48	III.	12 30
1889·257	163·9	72·47		

(30) OΣ 179 = κ *Geminorum* (4—8·5)

R.A. 7^h $37.^m8$. Dec. +24° 40′.

	°	″		h m
1889·228	233·6	6·16	III.	10 40
1889·234	234·5	6·23	IV.	9 40
1889·231	234·05	6·19		

(31) Σ 1187 = 85 *Lyncis* (7·1—8)

R.A. 8^h $2.^m6$. Dec. +32° 34′.

	°	″		h m
1890·247	47·0	2·30	V.	11 40
1890·253	47·9	2·19	V.	11 55
1890·305	48·6	2·32	III.	11 40
1890·268	47·8	2·27		

Retrograde motion and increase of distance.

(32) Σ 1196 = ζ *Cancri* (5—5·7—5·5)

R.A. 8^h $5.^m3$. Dec. +18° 0′.

A—B.

	°	″		h m
1888·362	41·4	1·13	V.	12 35

	°	″		h m	
1889·286	40·0	1·06	V.	10 15	
1889·294	41·4	1·06	V.	11 0	
1889·299	41·4	1·10	III*b*.	10 45	
1889·293	40·9	1·07			
	°	″		h m	
1891·217	34·3	1·28	IV.	10 35	
1891·233	34·1	1·19	V.	10 35	
1891·316	32·8	1·18	IV.	10 30	Very unsteady.
1891·255	33·7	1·22			

A—C.

	°	″		h m
1888·362	120·0	5·92	V.	12 50
	°	″		h m
1889·286	119·9	5·34	V.	11 15
1889·294	119·4	5·30	V.	11 15
1889·299	119·5	5·35	III*b*.	11 10
1889·293	119·6	5·33		
	°	″		h m
1891·217	117·7	5·33	IV.	11 0
1891·233	116·0	5·29	V.	11 5
1891·316	117·1	5·39	IV.	11 0
1891·255	116·9	5·34		

(33) Σ 1224 = ν' *Cancri* (6—7·1)

R.A. 8h 20.m1. Dec. + 24° 54′.

	°	″		h m
1890·305	43·4	5·85	III.	12 35
1890·324	42·7	5·79	IV.	12 5
1890·384	42·9	5·80	III.	13 20
1890·338	43·0	5·81		

(34) Σ 1223 = ϕ^2 *Cancri* (6—6·5)

R.A. 8h 20.m1. Dec. + 27° 18′.

	°	″		h m
1890·277	35·9	5·19	III.	11 40
1890·305	36·0	4·80	III.	12 10
1890·324	36·0	4·77	IV.	12 20
1890·302	36·0	·92		

(35) Σ 1263 (7·6—8·2)

R.A. 8^h $37.^m8$. Dec. +42° 6′.

	°	″		h m
1888·362	18·9	47·14	III.	13 10
1890·305	20·45	47·53	III.	13 10
1889·333	19·7	47·33		

(36) Σ 1273 = ϵ *Hydræ* (4—8)

R.A. 8^h $41.^m0$. Dec. +6° 49′.

	°	″		h m
1888·365	225·1	3·53	III.	12 10
1888·403	223·2	3·27	III.	13 0
1888·384	224·2	3·40		

	°	″		h m
1890·324	227·6	3·14	IV.	11 30
1890·373	227·6	3·18	IV.	12 30
1890·348	227·6	3·16		

(37) Σ 1291 = σ^2 *Cancri* (5·9—6·4)

R.A. 8^h $47.^m5$. Dec. +31°.

	°	″		h m
1889·294	325·2	1·36	IV.	12 45
1889·299	327·2	1·37	III*b*.	12 0
1889·302	327·6	1·47	V.	11 40
1889·298	326·7	1·40		

(38) OΣ 196 = ι *Ursæ Majoris* (3·1—10·3)

R.A. 8^h $51.^m7$. Dec. +48° 29′.

	°	″		h m
1889·327	358·2	8·80	II.	13 55
1889·406	359·0	8·98	II.	14 45
1890·384	357·4	8·60	III.	14 15
1889·705	358·2	8·79		

(39) Σ 1334 = 38 *Lyncis* (4—6·7)

R.A. 9^h $12.^m0$. Dec. +37° 17′.

	°	″		h m
1889·324	236·3	3·07	III.	12 30
1889·327	238·0	2·95	IV.	13 35
1889·330	237·6	2·96	IV.	12 20
1889·327	237·3	2·99		

(40) OΣ 200 (6·7—8·4)

R.A. 9^h $17.^m3$. Dec. + 52° 2′.

	°	″		h m
1890·409	334·8	1·46	V.	14 10
1890·428	334·6	1·50	IV.	15 10
1890·418	334·7	1·48		

(41) Σ 1374 = 30 (B) *Leonis Minoris* (7—8·3)

R.A. 9^h $34.^m6$. Dec. + 39° 27′.

	°	″		h m
1890·324	282·8	3·40	III.	13 10
1890·373	282·8	3·48	III.	13 15
1890·384	283·8	3·50	III.	13 50
1890·360	283·1	3·46		

(42) OΣ 215 (7—7·2)

R.A. 10^h $10.^m3$. Dec. + 18° 17′.

	°	″		h m
1889·294	215·0	0·76	V.	13 15
1889·299	217·2	0·77	III*b*.	12 45
1889·321	213·2	0·78	V.	12 0
1889·324	212·1	0·81	IV.	11 20
1889·327	213·3	0·77	V.	12 30
1889·322	214·2	0·78		

(43) Σ 1424 = γ *Leonis* (2—3·5)

R.A. 10^h $13.^m9$. Dec. + 20° 24′.

	°	″		h m	
1888·384	112·7	3·64	II*b*.	8 30	
1888·392	115·9	3·36	III.	13 0	Bad seeing.
1888·398	114·3	3·23	III.	14 40	
1888·391	114·3	3·41			

(44) Σ 1431 = P. X. 67 (8—9·5)

R.A. 10^h $19.^m5$. Dec. + 9° 20′.

	°	″		h m
1888·392	70·37	4·04	III.	14 10
1888·398	70·54	3·43	III.	11 30
1889·305	70·35	3·50	IV.	12 50
1888·698	70·42	3·66		

(45) Σ 1450 = 49 *Leonis* (6—8·7)

R.A. $10^h\ 29.^m2$. Dec. $+9°\ 14'$.

	°	″		h m	
1889·305	156·9	2·68	IV.	13 20	
1889·324	156·7	2·46	IV.	12 0	
1889·327	157·4	2·50	IV.	12 45	
1889·319	157·0	2·55			

(46) Σ 1457 (7·4—8·4)

R.A. $10^h\ 32.^m0$. Dec. $+6°\ 20'$.

	°	″		h m	
1889·327	312·4	1·10	IV.	13 5	
1889·384	311·5	1·19	IV.	13 30	
1890·400	316·7	1·35	IV.	13 55	Stars faint.
1889·704	313·5	1·21			

(47) Σ 1487 = 54 *Leonis* (4·5—7)

R.A. $10^h\ 49.^m7$. Dec. $+25°\ 20'$.

	°	″		h m	
1888·420	104·0	5·98	III.	15 0	
1888·480	105·8	6·17	III.	15 50	
1889·324	104·7	5·98	II.	13 15	
1888·741	104·8	6·04			

(48) Σ 1523 = ξ *Ursæ Majoris* (4—5)

R.A. $11^h\ 12.^m3$. Dec. $+32°\ 9'$.

	°	″		h m	
1888·450	224·8	2·23	IV.	15 30	
1888·499	221·5	2·50	IV.	15 40	Bad seeing.
1888·540	221·9	1·84	III*b*.	17 0	
1888·560	222·8	2·23	IV.	17 10	
1888·512	222·7	2·20			

	°	″		h m
1889·330	216·4	1·88	IV.	13 20
1889·384	217·4	1·76	IV.	14 15
1889·387	216·8	1·78	IV.	14 40
1889·367	216·9	1·81		

	°	″		h m	
1890·390	209·2	1·94	V.	14 30	
1890·400	208·9	1·97	IV.	14 15	Unsteady.
1890·409	209·3	1·98	V.	14 35	
1890·400	209·1	1·96			
	°	″		h m	
1891·463	200·15	1·72	V.	16 5	
1891·466	199·9	1·78	V.	15 30	
1891·482	199·8	1·72	V.	16 15	
1891·470	199·9	1·74			

(49) Σ 1527 = *Leonis* 339 (B) (7—8)

R.A. 11^h $13.^m2$. Dec. +14° 53′.

	°	″		h m	
1888·250	13·3	4·23	III.	9 40	
1888·256	13·8	4·14	III.	9 10	
1888·253	13·55	4·18			

(50) Σ 1536 = ι *Leonis* (4—7·5)

R.A. 11^h $18.^m2$. Dec. +11° 8′.

	°	″		h m	
1888·398	60·9	2·47	IV.	15 0	
1888·420	62·7	3·02	III.	14 45	Bad seeing.
1888·430	60·5	2·45	II*b*.	15 0	
1888·416	61·4	2·64			

(51) OΣ 235 (6—7·3)

R.A. 11^h $26.^m1$. Dec. +61° 42′.

	°	″		h m	
1888·560	78·4	1·28	V.	17 40	
	°	″		h m	
1891·521	86·3	1·03	V.	18 10	
1891·540	86·9	1·01	III*b*.	17 40	
1891·559	86·1	1·07	V	19 15	
1891·540	86·4	1·04			

(52) Σ 1670 = γ *Virginis* (3—3)

R.A. 12^h $36.^m1$. Dec. −0° 51′.

	°	″		h m	
1888·349	155·0	5·39	III.	12 45	
1888·461	155·3	5·20	III	5 0	
1888·405	155·15	5·29			

	°	″		h m
1891·452	154·0	5·30	III.	16 20
1891·463	153·2	5·65	III.	15 40
1891·466	154·2	5·48	IV.	15 10
1891·460	153·8	5·48		

(53) Σ 1699 (7·8—7·8)

R.A. 12^h $53.^m5$. Dec. $+28°$ 7′.

	°	″		h m	
1888·349	1·2	1·62	III.	13 15	
1890·428	2·5	...	IV.	15 50	Stars faint.
1890·436	2·0	1·58	IV.	16 25	
1889·737	1·9	1·60			

(54) OΣ 261 (6·9—7·4)

R.A. 13^h $6^m.0$. Dec. 32° 43′.

	°	″		h m
1891·540	348·9	1·40	III*b*.	18 15
1891·562	348·8	1·43	V.	17 50
1891·565	348·7	1·39	V.	17 40
1891·556	348·8	1·41		

(55) Σ 1734 (7·2—7·9)

R.A. 13^h $15.^m1$. Dec. $+3°$ 31′.

	°	″		h m
1888·392	190·2	1·42	V.	14 30
1888·398	191·9	1·21	IV.	14 40
1890·417	190·4	1·36	V.	15 10
1889·069	190·8	1·33		

(56) Σ 1744 = ζ *Ursæ Majoris* (*Mizar*) (2·1—4·2)

R.A. 13^h $19.^m5$. Dec. $+55°$ 30′.

	°	″		h m
1888·540	149·2	14·24	II*b*.	16 50

(57) β 114 = *Weisse* XIII., 438 (7·6—8·6)

R.A. 13^h $28.^m5$. Dec. $-7°$ 57′.

	°	″		h m
1889·420	136·3	1·43	IV.	15 30
1890·384	140·2	1·81	V.	14 50
1890·417	137·4	1·49	IV.	14 40
1890·074	138·0	1·58		

(58) Σ 1757 = P. XIII. 127 (7·8—8·9)

R.A. 13^h $28.^m9$. Dec. + 0° 15′.

	°	″		h m	
1889·420	71·8	2·31	IV.	16 10	
1890·384	71·2	2·59	V.	15 20	
1890·390	74·7	2·61	IV.	14 55	Bad seeing.
1890·065	72·6	2·50			

(59) Σ 1768 = 25 *Canum Venaticorum* (5—7·6)

R.A. 13^h $33^m.0$. Dec. + 36° 46′.

	°	″		h m	
1891·482	143·9	0·72	V.	17 10	
1891·521	142·1	1·22	V.	17 35	Indiff. seeing.
1891·532	144·7	0·85	V.	18 10	
1891·512	143·6	0·93			

(60) Σ 1788 (6·7—7·9)

R.A. 13^h $49.^m2$. Dec. − 7° 31′.

	°	″		h m
1890·400	75·3	2·63	IV.	14 50
1891·482	76·5	2·57	III.	15 45
1891·485	76·5	...	II*b*.	16 0
1891·122	76·1	2·60		

(61) Σ 1820 (8·2—8·5)

R.A. 14^h $9.^m4$. Dec. + 55° 50′.

	°	″		h m
1888·560	70·8	2·37	IV.	18 10
1888·604	71·0	2·91	III.	18 20
1888·617	70·8	2·35	III.	18 30
1888·594	70·9	2·54		

(62) Σ 1821 = κ *Boötis* (5·1—7·2)

R.A. 14^h $9.^m5$. Dec. + 52° 18′.

	°	″		h m
1889·595	236·4	12·98	III.	21 0
1889·625	237·0	12·90	III.	18 40
1889·610	236·7	12·94		

(63) Σ 1819 (7·9—8)

R.A. 14^h $9.^m8$. Dec. +3° 39′.

	°	″		h m	
1891·466	188·6	1·43	V.	16 0	
1891·496	189·2	1·32	III*b*.	16 40	
1891·499	190·8	1·50	III.	17 40	
1891·487	189 5	1·42			

(64) Σ 1864 = π *Boötis* (4·9—6)

R.A. 14^h $35.^m6$. Dec. +16° 53′.

	°	″		h m
1888·604	103·1	5·49	III.	19 15
1888·617	102·3	5·44	III.	19 45
1888·610	102·7	5·46		

(65) Σ 1865 = ζ *Boötis* (3·5—3·9)

R.A. 14^h $36.^m2$. Dec. +14° 12′.

1891·496 Elongated slightly in direction of 90°, with powers III*b*. (= 430) and IV*b*. (= 600). Beautifully seen with latter power.

(66) Σ 1877 = ε *Boötis* (3—6·3)

R.A. 14^h $40.^m2$. Dec. +27° 32′.

	°	″		h m	
1888·631	325·1	2·98	III.	18 50	Bad seeing.
1888·642	323·1	2·98	IV.	20 5	
1888·660	324·1	...	IV.	18 50	
1888·644	324·1	2·98			

	°	″		h m	
1889·598	326·9	2·88	IV.	19 30	Bad seeing.
1889·625	325·9	2·80	IV.	19 20	,, ,,
1889·655	327·8	2·76	IV.	19 30	
1889·661	329·0	2·80	IV.	19 45	
1889·686	328·0	2·67	V.	18 45	
1889·645	327·5	2·78			

(67) Σ 1888 = ξ *Boötis* (4·7—6·6)

R.A. 14^h $46.^m3$. Dec. +19° 33′.

	°	″		h m
1888·620	254·1	3·55	III.	18 40
1888·623	253·6	3·48	III.	18 40
1888·621	253·9	3·51		

	°	″		h m	
1889·598	249·9	3·33	IV.	20 15	
1889·623	249·7	3·31	IV.	18 45	
1889·625	250·0	3·28	IV.	19 10	
1889·615	249·9	3·31			

	°	″		h m	
1890·390	245·1	3·13	IV.	15 30	
1890·409	246·4	3·16	IV.	15 10	
1890·428	247·1	3·16	IV.	16 5	
1890·409	246·2	3·15			

	°	″		h m	
1891·463	244·3	3·14	IV.	17 15	
1891·466	243·6	3·34	IV.	16 40	Unsteady.
1891·482	242·9	3·04	V.	16 40	
1891·496	242·7	3·22	III*b*.	18 40	
1891·477	243·4	3·18			

(68) OΣ 287 (7·5—7·6)

R.A. 14^h 47.^{m}4. Dec.+45° 23′.

	°	″		h m
1891·628	318·0	0·75	V.	19 20
1891·674	316·0	0·67	V.	19 40
1891·677	320·2	0·78	V.	21 0
1891·660	318·1	0·73		

(69) OΣ 288 (6·4—7·1)

R.A. 14^h 48.^{m}2. Dec.+16° 10′.

	°	″		h m	
1890·546	192·7	1·50	V.	17 50	
1891·463	190·8	1·63	IV.	16 50	Very faint.
1891·466	193·9	1·39	IV.	16 30	
1891·158	192·5	1·51			

(70) Σ 1909 = 44 *Boötis* (5·2—6·1)

R.A. 15^h 0.^{m}2. Dec.+48° 5′.

	°	″		h m
1889·595	240·4	4·94	III.	20 40
1889·625	240·3	4·74	IV.	19 50
1889·610	240·35	4·84		

(71) Σ 1910 (7—7)

R.A. $15^h\ 2.^m3$. Dec. $+9°\ 39'$.

	°	″		h m
1890·477	210·9	4·20	IV.	17 5
1890·546	210·1	4·36	III.	17 10
1890·554	210·4	4·18	III.	17 30
1890·526	210·5	4·25		

Probably fixed.

(72) Σ 1934 (8·5—8·5)

R.A. $15^h\ 13.^m6$. Dec. $+44°\ 12'$.

	°	″		h m
1889·705	31·5	...	III.	20 20
1889·707	31·2	6·56	III.	21 15
1889·713	30·8	6·74	III.	20 40
1889·708	31·2	6·65		

Considerable change of angle, and slight increase in distance.

(73) Σ 1932 = 1 (B) *Coronæ Borealis* (5·6—6·1)

R.A. $15^h\ 14.^m9$. Dec. $+27°\ 34'$.

	°	″		h m
1891·562	313·9	0·99	V.	18 45
1891·565	315·0	0·96	V.	18 10
1891·611	314·1	1·08	V.	19 5
1891·579	314·3	1·01		

(74) Σ 1937 = η *Coronæ Borealis* (5·2—5·7)

R.A. $15^h\ 18.^m8$. Dec. $+30°\ 42'$.

	°	″		h m	
1891·496	220·9	0·84	III*b*.	18 20	
1891·559	223·5	0·75	V.	19 50	Splendid seeing
1891·562	221·7	0·65	V.	18 20	
1891·539	222·0	0·75			

(75) Σ 1938 = μ^2 *Boötis* (6·7—7·3)

R.A. $15^h\ 20.^m4$. Dec. $+37°\ 46'$.

	°	″		h m
1888·652	97·6	0·73	V.	18 20
1889·686	98·3	0·73	V.	19 15
1889·713	97·6	0·74	IV.	21 15
1889·350	97·8	0·73		

(76) Σ 1954 = δ *Serpentis* (3·9—5·6)

R.A. 15^h $29.^m6$. Dec. + 10° 54′.

	°	″		h m	
1888·617	190·4	3·42	III.	19 0	
1888·620	190·8	3·51	III.	19 45	
1888·685	188·0	...	III.	19 35	
1888·693	188·1	3·61	III.	19 25	Flaring.
1888·654	189·3	3·51			

(77) Σ 1965 = ζ *Coronæ Borealis* (4·1—5)

R.A. 15^h $35.^m2$. Dec. + 37° 0′.

	°	″		h m
1889·705	302·1	5·98	III.	19 50
1889·707	301·3	5·87	III.	20 40
1889·706	301·7	5·92		

(78) OΣ 303 (7·4—7·9)

R.A. 15^h $55.^m7$. Dec. + 13° 25′.

	°	″		h m	
1891·496	138·3	0·95	III*b*.	17 50	
1891·521	139·5	0·97	V.	17 5	
1891·532	141·9	1·01	V.	17 50	Stars dim.
1891·516	139·9	0·97			

(79) Σ 2010 = κ *Herculis* (5—6)

R.A. 16^h $3.^m1$. Dec. + 17° 20′.

	°	″		h m
1888·620	11·0	29·53	II.	20 0

(80) Σ 2021 = 49 *Serpentis* (6·7—6·9)

R.A. 16^h $8.^m2$. Dec. + 13° 49′.

	°	″		h m
1888·604	330·0	4·03	III.	19 10
1888·617	330·7	3·97	III.	20 15
1888·610	330·35	4·00		

(81) Σ 2032 = σ *Coronæ Borealis* (5—6·1—10)

R.A. $16^h\ 11.^m0$. Dec. +34° 12′.

A—B.

	°	″		h m
1888·604	208·0	3·85	III.	19 40
1888·623	207·6	3·71	III.	19 10
1888·642	207·7	3·94	IV.	20 15
1888·623	207·8	3·83		

A—D.

	°	″		h m
1888·623	88·2	57·58	III.	19 25

The companion C not seen.

(82) Σ 2054 = *Draconis* 99 (B) (5·7—6·9)

R.A. $16^h\ 22.^m1$. Dec. +61° 57′.

	°	″		h m
1889·680	357·1	1·07	IV.	22 10
1889·686	356·7	1·16	V.	20 15
1889·707	361·4	1·10	IV.	22 10
1889·691	358·4	1·11		

(83) OΣ 312 = η *Draconis* (2·1—8·1)

R.A. $16^h\ 22.^m5$. Dec. +61° 46′.

	°	″		h m
1889·680	144·0	4·93	IV.	22 25
1889·686	142·1	4·88	IV.	20 30
1889·707	142·1	4·71	III.	21 40
1889·691	142·7	4·84		

(84) Σ 2049 (6·5—7·5)

R.A. $16^h\ 23.^m4$. Dec. +26° 14′.

	°	″		h m
1891·628	208·6	1·02	V.	18 50
1891·674	207·7	...	V.	20 5
1891·677	208·4	1·22	IV.	21 40
1891·685	210·7	1·27	IV.	21 0
1891·666	208·8	1·17		

(85) Σ 2055 = λ *Ophiuchi* (4—6·1)

R.A. 16^h $25^m.0$. Dec. + 2° 13′.

	°	″		h m
1888·693	45·25	1·97	V.	19 25
1888·696	41·6	1·64	II*b*.	19 40
1888·718	39·2	1·48	V.	18 55
1888·702	42·0	1·70		

	°	″		h m
1891·611	42·3	1·76	IV.	19 35
1891·674	46·0	1·55	V.	20 30
1891·642	44·15	1·65		

(86) OΣ 313 (7·2—7·8)

R.A. 16^h $29.^m3$. Dec. + 40° 20′.

	°	″		h m	
1889·661	151·3	0·94	V.	20 55	
1889·666	152·5	0·83	V.	19 40	
1890·685	147·7	0·93	V.	21 30	Stars faint.
1890·004	150·5	0·90			

(87) Σ 2084 = ζ *Herculis* (3—6·5)

R.A. 16^h $37.^m2$. Dec. + 31° 48′.

	°	″		h m
1888·642	72·7	1·74	IV.	21 20
1888·652	75·8	1·68	V.	18 20
1888·660	76·1	1·71	IV.	21 30
1888·651	74·9	1·71		

	°	″		h m
1889·655	70·14	1·82	IV.	20 0
1889·661	70·7	1·66	V.	20 35
1889·666	69·8	1·72	V.	20 10
1889 661	70·2	1·73		

	°	″		h m
1890·696	65·24	1·63	V.	21 45
1890·699	67·4	1·71	V.	21 30
1890·702	64·7	1·71	V.	20 0
1890·699	65·8	1·68		

	°	″		h m
1891·611	60·8	1·42	V.	20
1891·628	60·2	1·50	V.	19 40
1891·655	59·2	1·29	V.	20 0
1891·631	60·1	1·40		

(88) OΣ 315 = 21 *Ophiuchi* (6·2—8·1)

R.A. 16^h $45.^m8$. Dec. + 1° 24′.

	°	″		h m
1889·686	161·3	0·78	V.	19 50
	°	″		h m
1891·496	158·5	0·94	III*b*.	17 15
1891·499	158·8	0·92	V.	18 10
1891·498	158·65	0·93		

(89) Σ 2120 = 210 *Herculis* (6·4—9·2)

R.A. 17^h $0^m.0$. Dec. + 28° 15′.

	°	″		h m
1888·660	248·4	6·16	IV.	20 45
1888·685	247·7	6·02	IV.	20 20
1888·672	248·0	6·09		

(90) Σ 2130 = μ *Draconis* (5—5·1)

R.A. 17^h $3^m.0$. Dec. + 54° 37′.

	°	″		h m
1888·696	157·9	2·64	II*b*.	21 50
1888·724	158·6	2·46	IV.	21 20
1888·727	157·9	2·32	IV.	21 20
1888·716	158·1	2·47		
	°	″		h m
1889·699	157·1	2·41	IV.	22 15
1889·707	158·0	2·40	IV.	22 35
1889·713	157·7	2·45	IV.	22 0
1889·706	157·6	2·42		

(91) Σ 2135 (7·1—8·4)

R.A. 17^h $7.^m4$. Dec. + 21° 21′.

	°	″		h m
1888·660	175·1	7·04	IV.	20 0
1888·685	174·9	7·23	IV.	20 40
1888·672	175·0	7·13		

(92) Σ 2140 = α *Herculis* (3—6·1)

R.A. 17^h 9.^{m}6. Dec. + 14° 35′.

	°	″		h m
1888·650	114·3	4·72	III.	16 30
1888·652	114·9	4·61	III.	17 20
1888·651	114·6	4·66		

(93) Σ 3127 = δ *Herculis* (3—8·1)

R.A. 17^h 10.^{m}5. Dec. + 24° 58′.

	°	″		h m
1888·693	187·15	16·63	IV.	20 45

(94) Σ 2161 = ρ *Herculis* (4—5·1)

R.A. 17^h 19.^{m}9. Dec. + 37° 15′.

	°	″		h m
1888·623	311·4	3·68	III.	20 5
1888·642	310·2	3·62	IV.	20 30
1888·632	310·8	3·65		

(95) Σ 2173 (5·8—6·1)

R.A. 17^h 24.^{m}5. Dec. — 0° 58′.

	°	″		h m
1890·554	344·3	0·94	V.	18 30
1890·740	342·1	0·75	V.	20 50
1890·778	342·9	0·84	V.	19 35
1890·691	343·1	0·84		

(96) Σ 2218 (6·5—7·7)

R.A. 17^h 39.^{m}6. Dec. + 63° 44′.

	°	″		h m
1889·661	345·8	1·98	IV.	22 5
1889·699	345·4	2·13	IV.	22 40
1889·713	346·3	2·09	IV.	22 45
1889·691	345·8	2·07		

Apparently slow diminution of angle and distance.

(97) Σ 2213 = *Herculis* 331 (B) (7·5—8)

R.A. 17^h 40.^{m}7. Dec. + 31° 11′.

	°	″		h m
1889·746	328·6	4·62	III.	22 30
1889·759	329·5	4·84	III.	21 55
1889·752	329·05	4·73		

Change doubtful.

(98) OΣ 338 (6·6—6·9)

R.A. 17^h $47^m.0$. Dec. + 15° 21′.

	°	″		h m
1889·666	20·4	0·79	V.	19 20
1889·686	21·9	...	V.	21 5
1889·833	21·2	0·89	IV.	21 15
1889·728	21·2	0·84		

Retrograde motion, with some increase in distance.

(99) β 130 = 90 *Herculis* (5·8—9·1)

R.A. 17^h $49.^m7$. Dec. 40° 2′.

	°	″		h m
1888·652	121·6	1·51	IV.	19 20
1888·685	121·1	1·76	IV.	21 40
1889·655	121·6	...	IV.	21 0
1889·680	121·7	...	IV.	21 50
1889·167	121·5	1·63		

Very difficult pair with moderate apertures, but exceedingly beautiful when well seen. No decided evidence of motion. The following are believed to be the only published measures :

	°	″		
1875·520	123·0	1·82	De.	6 nights.
1879·471	118·6	1·76	β.	1 night.
1881·460	122·2	1·90	β.	4 nights.
1888·426	123·3	1·67	Tarrant.	3 „

(100) β 417 (8—9·5)

R.A. 17^h $52.^m5$. Dec. + 39° 27′.

	°	″		h m
1889·655	269·7	1·49	IV.	21 30
1889·661	272·1	1·38	IV.	21 40
1889·658	270·9	1·43		

(101) Σ 2262 = τ *Ophiuchi* (5—5·7)

R.A. 17^h $57.^m1$. Dec. − 8° 11′.

	°	″		h m
1888·696	256·1	2·18	II*b*.	20 30
1888·718	255·1	1·65	V.	20 10
1888·724	254·4	1·56	IV.	18 40
1888·712	255·2	1·80		

Direct motion, with marked increase in distance.

(102) Σ 2272 = 70 *Ophiuchi* (4·4—6·1)

R.A. 18h 0m.0. Dec. + 2° 33′.

	°	″		h m	
1888·450	355·9	...	IV.	16 20	Bad seeing.
1888·510	349·9	2·08	II*b*.	17 40	
1888·540	352·2	2·12	III*b*.	18 10	
1888·560	356·5	2·20	IV.	19 10	
1888·620	356·7	...	IV.	19 30	Bad seeing.
1888·642	356·0	2·28	IV.	19 20	
1888·553	354·5	2·17			
	°	″		h m	
1889·598	347·1	2·06	IV.	19 10	
1889·625	346·6	1·91	IV.	20 20	
1889·655	346·5	2·03	IV.	20 30	
1889·661	346·0	1·90	IV.	20 10	
1889·666	346·0	1·92	IV.	18 45	
1889·641	346·4	1·96			
	°	″		h m	
1890·546	336·5	1·94	IV.	18 40	
1890·554	336·5	2·00	V.	18 5	
1890·729	336·6	2·09	IV.	21 10	
1890·609	336·5	2·01			
	°	″		h m	
1891·521	328·6	2·05	V.	18 40	
1891·532	328·9	2·02	V.	18 45	
1891·540	328·3	2·20	III*b*.	19 5	
1891·562	327·6	2·16	V.	19 15	
1891·539	328·3	2·11			

103) Σ 2279 = 417 *Herculis* (6—7·1)

R.A. 18h 5.m2. Dec. + 16° 27′.

	°	″		h m
1890 685	230·9	0·98	V.	22 5
1890·688	231·6	1·12	V.	21 30
1890·696	232·0	1·07	V.	21 15
1890·689	231·5	1·06		

(104) β 641 = L 33897 (7—9)

R.A. 18h 17m.0. Dec. + 21° 27′.

	°	″		h m	
1890·685	357·3	1·12	V.	22 30	
1890·740	357·0	0·93	IV.	21 55	Very faint.
1890·712	357·1	1·02			

(105) OΣ 358 (6·8—7·2)

R.A. 18h 31m. Dec. + 16° 50′.

	°	″		h m
1888·718	197·8	1·79	IV.	21 30
1888·724	199·8	1·65	IV.	22 30
1888·787	197·6	1·74	IV.	21 20
1888·743	198·4	1·73		

(106) *a Lyræ (Vega)* (1—11)

R.A. 18h 33.m2. Dec. + 38° 41′.

	°	″		h m
1888·762	158·6	49·79	III.	22 30

(107) Σ 2372 (6·7—8·2)

R.A. 18h 38.m3. Dec. + 34° 39′.

	°	″		h m
1888·784	83·0	24·68	III.	23 50

(108) Σ 2375 (6·2—6·6)

R.A. 18h 40.m5. Dec. + 5° 23′.

	°	″		h m
1889·699	112·0	2·12	IV.	21 15
1889·710	113·5	1·92	IV.	21 15
1889·779	111·8	2·13	IV.	20 5
1889·833	114·0	...	IV.	21 40
1889·755	112·8	2·06		

(109) ϵ^1—ϵ^2 *Lyræ* (4·6—4·9)

R.A. 18h 40.m7. Dec. + 39° 33′.

	°	″		h m
1888·683	172·65	206·9	IV.	22 20

(110) Σ 2382 = ϵ^1 *Lyræ* (4·6—6·3)

R.A. 18^h $40.^m7$. Dec. + 39° 33′.

	°	″		h m	
1888·751	13·9	3·38	III.	23 15	Bad seeing.
1888·762	16·1	3·36	III.	22 50	
1888·784	16·6	3·10	IV.	22 30	
1888·787	14·8	2·98	IV.	22 50	
1888·771	15·35	3·20			

(111) Σ 2383 = ϵ^2 *Lyræ* (4·9—5·2)

R.A. 18^h $40.^m7$. Dec. + 39° 29′.

	°	″		h m
1888·762	132·2	2·52	III.	23 30
1888·784	134·2	2·35	IV.	22 45
1888·787	132·7	2·37	IV.	23 5
1888·778	133·0	2·41		

(112) β 265 = L 35060 (7·1—9·1)

R.A. 18^h $45.^m1$. Dec. + 11° 23′.

	°	″		h m	
1888·724	231·2	1·36	V.	22 45	Seeing indifferent.
1888·727	236·4	1·53	IV.	21 15	,, ,,
1890·702	235·1	1·49	IV.	20 55	
1889·384	234·2	1·46			

Apparently fixed.

(113) Σ 2422 (7·6—7·7)

R.A. 18^h $52.^m4$. Dec. + 25° 57′.

	°	″		h m
1889·836	95·9	0·80	V.	20 55
1891·628	93·0	0·86	V.	20 10
1891·674	93·6	0·88	V.	21 15
1891·046	94·2	0·85		

(114) Σ 2441 (7·7—9·3)

R.A. 18^h $58.^m5$. Dec. + 31° 14′.

	°	″		h m
1888·801	279·8	5·17	III.	20 40
1891·628	279·1	5·22	IV.	20 40
1891·674	279·4	5·19	IV.	22 30
1890·701	279·4	5·19		

(115) Σ 2446 = P.$^{\text{XVIII. 302}}$ (7·5—9)

R.A. 19^h $0.^m5$. Dec. + 6° 23′.

	°	″		h m
1888·727	154·1	9·83	IV.	21 50
1888·751	152·8	9·66	III.	22 15
1888·739	153·4	9·74		

(116) Σ 2455 = L 35821 (7·2—8·3)

R.A. 19^h $2.^m3$. Dec. + 22° 0′.

	°	″		h m
1888·751	91·2	3·61	III.	22 0
1888·762	92·2	3·64	III.	22 30
1888·756	91·7	3·62		

(117) Σ 2461 = 17 *Lyræ* (6—11)

R.A. 19^h $3.^m3$. Dec. + 32° 20′.

	°	′		h m
1888·652	313·4	3·60	IV.	21 20
1888·762	312·1	3·76	III.	21 55
1888·707	312·7	3·68		

Magnitude of *comes* appears underrated. Certainly quite 10 mag.

(118) β 248 = 2 *Vulpeculæ* (5·8—9·6)

R.A. 19^h $12.^m9$. Dec. + 22° 51′.

	°	″		h m
1888·683	125·8	1·62	IV.	21 45
1888·685	124·4	1·77	IV.	22 0
1888·684	125·1	1·69		

A very difficult pair. Apparently fixed. The following are believed to be all the published measures :

	°	″		
1876·110	125·0	1·86	De.	6 nights.
1881·640	124·7	1·78	Ho.	2 ,,
1887·758	134·16	2·12	Tarrant.	6 ,,
1888·724	128·21	2·00	,,	5 ,,
1890·630	125·4	1·86	[β.	3 ,,

(119) Σ 2509 = P. XIX. 108 (7—8·1)

R.A. 19^h $15.^m7$. Dec. +62° 50′.

	°	″		h m
1889·759	338·8	0·99	IV.	23 30
1889·779	336·2	1·05	IV.	0 5
1889·836	338·6	0·89	IV.	23 50
1889·791	337·9	0·98		

Retrograde movement, with increase of distance.

(120) Σ 2521 = P. XIX. 128 (5·5—10·3)

R.A. 19^h $21.^m4$. Dec. + 19° 40′.

	°	″		h m
1890·705	39·0	24·50	I.	22 30
1890·754	39·0	24·52	II.	22 20
1890·730	39·0	24·51		

(121) Σ 43 App. I = β *Cygni* (3—5·3)

R.A. 19^h $26.^m3$. Dec. +27° 44′.

	°	″		h m
1889·746	54·5	34·36	III.	23 10

(122) β 144 = Arg. + 30°, 3664 (8·7—8·8)

R.A. 19^h $33.^m3$. Dec. +30° 16′.

	°	″		h m
1888·718	350·8	6·58	IV.	21 30
1888·831	351·3	6·56	III.	0 10
1888·774	351·0	6·57		

(123) Σ 2576 (7·8—7·8)

R.A. 19^h $41.^m4$. Dec. +33° 22′.

	°	″		h m
1890·779	295·9	2·86	III.	21 15
1890·818	295·4	2·97	IV.	0 10
1890·833	296·9	2·92	IV.	23 50
1890·810	296·1	2·92		

(124) Σ 2579 = δ *Cygni* (3—7·7)

R.A. 19^h $41.^m5$. Dec. +44° 52′.

	°	″		h m
1890·554	316·5	1·70	V.	18 0
1890·556	315·7	1·54	V.	18 15
1890·555	316·1	1·62		

(125) Σ 2583 = π *Aquilæ* (6—6·8)

R.A. 19^h $43.^m5$. Dec. +11° 33′.

				h m	
1888·751	116°·7	1″·43	IV.	22 45	
1888·787	116·8	1·31	IV.	21 40	
1888·769	116·75	1·37			

Retrograde movement, with some reduction in distance.

(126) OΣ 388 (7·6—7·6—8·8)

R.A. 19^h $47.^m4$. Dec. +25° 35′.

A—B.

				h m	
1889·836	138°·7	3″·76	III.	0 25	Stars faint.
1889·847	138·7	4·22	III.	0 50	„ „
1889 841	138·7	3·99			

B—C.

				h m	
1889·836	135°·8	26″·73	III.	0 40	Stars faint.

(127) Σ 2603 = ϵ *Draconis* (4—7·6)

R.A. 19^h $48.^m5$. Dec. +69° 59′.

				h m
1889·072	0°·7	2″·90	IV.	1 50
1889·124	1·4	2·83	IV.	7 30
1889·098	1·05	2·86		

(128) Σ 2675 = κ *Cephei* (4·5—8·5)

R.A. 20^h $12.^m6$. Dec. +77° 23′.

				h m
1888·286	122°·2	7″·49	III.	11 30

(129) β 63 = 1 *Delphini* (6·5—8)

R.A. 20^h $24.^m7$. Dec. +10° 32′.

				h m
1888·724	347°·5	0″·96	V.	23 30
1891·628	354·5	1·06	V.	20 55
1891·754	352·6	1·07	V.	21 55
1891·691	353·6	1·06		

(130) Σ 2725 (7·3—8)

R.A. $20^h\ 41.^m1$. Dec. $+15°\ 30'$.

	°	″		h m	
1888·718	1·5	4·94	IV.	23 0	Stars faint.
1888·801	3·0	4·74	IV.	23 55	„ „
1889·759	2·4	4·92	IV.	22 55	„ „
1889·093	2·3	4·87			

Increase in angle. Change in distance doubtful.

(131) Σ 2727 = *γ Delphini* (4—5·1)

R.A. $20^h\ 41.^m6$. Dec. $+15°\ 44'$.

	°	″		h m
1888·801	270·8	12·10	IV.	0 12
1888·803	270·6	10·98	III.	22 50
1888·806	270·9	10·68	II.	23 15
1888·803	270·8	11·25		

(132) *β* 66 (8—8)

R.A. $20^h\ 42.^m9$. Dec. $+27°\ 0'$.

	°	″		h m	
1889·899	159·9	1·70	IV.	0 50	Very faint.
1891·792	163·6	1·44	IV.	23 40	
1890·845	161·7	1·57			

(133) OΣ 413 = λ *Cygni* (5—6·3)

R.A. $20^h\ 43.^m1$. Dec. $+36°\ 8'$.

	°	″		h m
1889·847	70·27	0·64	V.	1 30
1889·863	70·70	0·68	V.	1 35
1889·855	70·48	0·66		

(134) Σ 2735 = P. XX. 376 (6—8)

R.A. $20^h\ 50.^m2$. Dec. $+4°\ 7'$.

	°	″		h m
1890·836	283·1	1·89	IV.	22 0
1891·737	283·5	2·08	IV.	22 30
1891·740	282·3	2·08	IV.	23 10
1891·438	283·0	2·02		

(135) Σ 2737 = ε *Equulei* (5·7—6·2—7·1)

R.A. 20h 54.m0. Dec. + 3° 53′.

A—B.

	°	″		h m
1889·779	283·7	0·91	V.	23 15
1889·836	282·1	0·86	IV.	23 10
1889·847	284·6	0·94	V.	23 55
1889·821	283·5	0·90		

A—C.

	°	″		h m
1889·779	73·0	9·96	IV.	23 30
1889·836	73·9	10·19	III.	23 25
1889·847	73·3	10·07	IV.	0 10
1889·821	73·4	10·07		

(136) Σ 2741 = P. XX. 429 (6—7·3)

R.A. 20h 55.m0. Dec. + 50° 2′.

	°	″		h m
1889·847	32·26	1·94	V.	2 5
1889·863	32·34	1·95	IV.	1 10
1889·855	32·30	1·94		

(137) Σ 2742 = 2 *Equulei* (6—6·5)

R.A. 20h 56.m8. Dec. + 6° 45′.

	°	″		h m
1890·696	222·4	2·59	V.	22 40
1890·699	222·8	2·62	V.	22 10
1890·702	222·6	2·69	IV.	22 10
1890·699	222·6	2·63		

(138) Σ 2744 (6·3—7)

R.A. 20h 57.m5. Dec. + 1° 6′.

	°	″		h m
1889·872	166·8	1·65	IV.	22 50
1889·899	166·9	1·74	IV.	23 10
1890·702	164·9	1·55	IV.	22 25
1890·157	166·2	1·65		

Very slow retrograde motion.

(139) Σ 2758 = 61 *Cygni* (5·3—5·9)

R.A. 21^h 2.^{m}0. Dec. + 38° 13′.

	°	″		h m
1888·831	121·0	20·45	III.	0 50
1888·850	121·4	20·75	III.	0 15
1888·840	121·2	20·60		

(140) OΣ 432 = P. XXI. 50 (6·8—7·2)

R.A. 21^h 10.^{m}1. Dec. + 40° 41′.

	°	″		h m
1888·899	126·1	1·33	IV.	1 35
1889·902	124·2	1·26	IV.	1 45
1889·913	124·7	1·26	IV.	2 20
1889·905	125·0	1·28		

(141) OΣ 437 (7·5—8)

R.A. 21^h 16.^{m}4. Dec. + 32° 0′.

	°	″		h m
1891·751	46·9	1·63	V.	23 5
1891·754	46·5	1·65	V.	23 50
1891·784	46·8	1·56	V.	0 20
1891·763	46·7	1·61		

(142) Σ 2797 (6·6—6·6)

R.A. 21^h 21.^{m}4. Dec. + 13° 13′.

	°	″		h m
1891·754	215·8	3·26	IV.	23 10
1891·770	217·4	3·35	IV.	23 15
1891·784	216·7	3·27	IV.	23 10
1891·769	216·6	3·29		

(143) Σ 2799 = 20 (B) *Pegasi* (6·6—6·6)

R.A. 21^h 23.^{m}3. Dec. + 10° 36′.

	°	″		h m
1889·899	304·7	1·52	IV.	1 15
1889·902	302·3	1·27	IV.	1 15
1890·030	301·8	1·25	IV.	0 40
1889·944	302·9	1·35		

Retrograde motion.

(144) Σ 2822 = μ *Cygni* (4—5)

R.A. 21^h $39.^m2$. Dec. +28° 15′.

	°	″		h m	
1888·858	120·3	3·31	IV.	0 40	
1888·888	120·6	3·07	IV.	1 10	
1888·891	120·2	3·30	IV.	1 30	
1888·879	120·4	3·23			

(145) β 75 (8—9)

R.A. 21^h $49.^m7$. Dec. +10° 19′.

	°	″		h m	
1891·754	40·4	1·72	V.	22 40	Stars dim.
1891·792	42·5	1·21	IV.	23 10	
1891·808	38·6	1·10	IV.	23 30	
1891·785	40·5	1·34			

(146) Σ 2848 (7·2—7·5)

R.A. 21^h $52.^m5$. Dec. +5° 25′.

	°	″		h m
1890·779	55·7	10·42	III.	22 0
1890·841	57·3	10·49	III.	23 40
1890·810	56·5	10·45		

(147) Σ 2863 = ξ *Cephei* (4·7—6·5)

R.A. 22^h $0.^m6$. Dec. +64° 5′.

	°	″		h m
1888·858	282·5	6·76	IV.	1 40
1888·888	281·0	6·59	IV.	1 40
1888·891	282·3	6·37	IV.	2 10
1891·067	282·5	6·48	IV.	5 50
1889·426	282·1	6·55		

(148) Σ 2881 (7·7—8·2)

R.A. 22^h $9.^m4$. Dec. +29° 0′.

	°	″		h m
1888·907	103·5	1·65	IV.	2 15
1888·987	102·7	1·53	IV.	2 30
1888·947	103·1	1·59		

(149) Σ 2878 = 148 *Pegasi* (6·5—8)

R.A. 22^h $9.^m5$. Dec. + 7° 26′.

	°	″		h m	
1888·987	129·1	1·29	IV.	0 45	
1889·836	129·1	1·17	IV.	1 10	
1889·411	129·1	1·23			

(150) Σ 2909 = ζ *Aquarii* (4—4·1)

R.A. 22^h $23.^m2$. Dec. − 0° 36′.

	°	″		h m	
1888·850	327·2	3·42	III.	23 45	
1888·858	327·1	3·21	IV.	0 10	Unsteady.
1888·904	323·7	3·56	IV.	1 10	Bad seeing.
1888·907	324·3	3·55	IV.	1 45	” ”
1888·929	325·3	3·38	III.	23 45	
1888·890	325·6	3·42			

	°	″		h m
1890·776	323·6	3·17	IV.	22 50
1890·779	324·6	3·03	IV.	22 25
1890·814	324·7	2·92	IV.	23 40
1890·790	324·3	3·04		

	°	″		h m
1891·770	324·8	3·08	IV.	23 50
1891·784	323·7	3·21	IV.	23 45
1891·792	323·4	3·01	IV.	0 20
1891·782	324·0	3·10		

(151) β 382 = B.A.C. 7983 (6—8)

R.A. 22^h $48.^m8$. Dec. + 44° 10′.

	°	″		h m
1888·987	217·3	0·98	V.	3 15
1889·902	221·3	1·08	V.	2 10
1889·444	219·3	1·03		

(152) OΣ 483 = 52 *Pegasi* (6·2—7·7)

R.A. 22^h $53.^m7$. Dec. +11° 8′.

	°	″		h m	
1889·899	215·4	1·16	V.	2 5	Indifferent seeing.
1891·740	215·0	1·21	V.	23 55	
1891·751	219·0	0·96	V.	23 45	
1891·754	218·1	1·06	V.	23 40	Splendid seeing.
1891·286	216·9	1·10			

(153) Σ 3050 = 37 (B) *Andromedæ* (6—6)

R.A. 23^h $53.^m9$. Dec. +33° 7′.

	°	″		h m
1889·902	208·7	3·01	IV.	2 40
1889·913	208·5	3·22	IV.	3 15
1889·940	208·6	3·02	IV.	2 40
1889·918	208·6	3·08		

On the Construction of a Five-foot Equatorial Reflecting Telescope.

By A. A. Common, LL.D., F.R.S.

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Introduction.

The excellent performance of an 18-inch silver-on-glass reflecting telescope mounted at Ealing in 1876, and also of a 3-foot of similar construction mounted in 1879, particularly in Astronomical Photography, induced me to attempt the construction of a larger telescope of the same kind. The perfectly satisfactory behaviour of the mounting adopted for the 3-foot mirror, described in a paper published in the *Memoirs of the Royal Astronomical Society*, vol. xlvi., led me to believe that the construction of a much larger equatorial reflector would be quite possible, if discs of good glass of sufficient size could be procured and correctly figured, even if the thickness most desirable could not be obtained.

The thickness of the 3-foot was about $4\frac{1}{2}$ inches, or, roughly, one-eighth of the diameter. This was found amply sufficient to prevent flexure, with the system of mounting adopted, but it was quite uncertain how far this proportion might be reduced without injuring the figure. The limit of size was dependent upon the weight of glass that could be cast.

After many inquiries I found that the French glass-makers were prepared to supply larger discs of glass than the English; the limit of weight being fixed at something over 500 kilogrammes. It was thought that the thickness might safely be reduced to one-twelfth of the diameter, and a disc

of 61 inches diameter and 5 inches thickness, with a central hole 10 inches across, was ordered in 1880 and delivered in 1882.

At this time I was not prepared to commence the work of grinding and polishing the disc, and it remained in the wooden case resting at an angle against a wall for about four years, and to this was attributed for some time the peculiarities which this particular disc exhibited as a mirror. But reason was found later on for changing this opinion.

In 1886 the serious work of making this disc of glass into a mirror was begun. It will probably be of interest to give a short account of this early work which led to the successful construction and mounting of a mirror of 5-foot aperture before I proceed to give in detail the method of work finally determined upon.

Every well-known worker hitherto, without exception, has begun by making small mirrors, and, as experience and skill were gained, has increased the size of the discs. This raised in my mind a great doubt as to the wisdom of my first intention, which was to commence at once with a mirror of 5-foot aperture. I had never attempted the grinding and polishing of glass, and had never seen a piece of glass worked ; all my experience extended to turning up in the lathe with a diamond tool some discs of glass procured in 1874 with a view of making a mirror of 18-inch aperture. The opportunity of obtaining by purchase a mirror of that diameter ready made, and the dictum of a most eminent astronomer, that it takes at least five years to acquire the art of speculum-making (in which, indeed, he was not very far wrong), were sufficient to stop further efforts on my part at that time, and, consequently, in 1886 I knew nothing of the practical working of glass. Considering, however, that any experience gained and any skill that might be acquired in making small mirrors which could be easily handled would be very different from that required in working a very large mirror on a machine, when the weights to be moved were so great that some mechanical arrangements were necessary for almost every operation, I determined to begin at once on the 5-foot disc, gaining experience by making successive mirrors by constantly regrinding and repolishing the same piece of glass.

A plan of work was sketched out in which an endeavour was made to adopt as far as circumstances permitted all the essential things that had been pointed out by previous workers.

Restrictions came in in several directions; for instance, while intending to arrange for making the mirror entirely by testing at the centre of curvature, as described by Foucault and Draper, the space in the garden in front of the workshop did not permit the adoption of the full method of Foucault of carrying the point of light farther and farther away beyond the centre of curvature. It was almost impossible to examine the image of a star formed by the mirror until it was mounted in the telescope, so that particular attention had to be paid to the testing at the centre of curvature. The great essential of the machine was, therefore, that, for testing purposes, it should be possible to turn the mirror into a vertical position without trouble. A combination of two reciprocating motions at right angles, combined with the rotation of the mirror, seemed to give all the movements that the tool required, and thus the general plan of the machine settled itself on those lines. In principle, the machine made and used for the 5-foot is similar to that employed by Grubb for making the mirror of the 4-foot Melbourne telescope.

With the exception of the two rods from the cranks to the tool no part of the mechanism is over the mirror, and consequently all danger of scratches due to grit falling from the machinery on to the mirror during fine grinding and polishing is avoided. In practice it is found that with the mirror rotating the tool also rotates, without any special mechanism for that purpose, in a perfectly regular manner if there is no unequal distribution of grinding or polishing material, an irregular rotation of the tool showing at once that something is wrong. One very important question arose—viz., whether the usual chamber in which the testing of mirrors at the centre of curvature is carried on could be dispensed with. So much has been said about the trouble from air-currents, even in a closed chamber, and the necessity of having, if possible, a place underground to carry on the testing in this manner, that it was with considerable doubt I determined to dispense entirely with any chamber or enclosure, and to test at night-time in what is really the open air. For this purpose the machine is placed close to gates in the outer wall of the grinding-room, and a large sentry-box in the open air is used to hold the lamps and the observer. This plan has answered admirably: in certain conditions of sky and temperature the image is as steady as can be wished; at other times, when the night temperature has fallen rapidly, the definition is not good;

but it is very rarely indeed that readings of the different zones are not easily taken to one-hundredth of an inch.

A focal length of 28 feet 7 inches was aimed at, as giving about six inches for one degree on the photographic plate, and templets made as accurately as possible to the corresponding curve were employed for rough measurement during the coarse grinding, though from one cause or another this focal length has been gradually shortened.

For this rough grinding coarse emery (No. 12) was used with a heavy lead tool, about 20 inches in diameter, which quickly ground out the glass approximately to the curve. This lead tool was used with different emeries, commencing with the coarsest and going up to No. 54; but beyond that, for finer grinding, an iron tool was employed, so that surfaces up to No. 150 emery, and even to flour emery, were obtained, and polishing and figuring of an experimental character were begun and carried on until some twenty different mirrors had been made and tested.

The usual plan with English makers has been to use as polishers large wooden tools of the same size as the mirror, and made of several thicknesses of wood crossed in layers. Several of them were built up for the polisher of the 5-foot, and were turned to the proper curve. When covered with pitch or resin they were found almost too much for my prime mover to deal with effectively; that difficulty could easily have been overcome, but a greater one presented itself. An enormous amount of heat was produced when these large polishers were used, and I was convinced that this would act injuriously on the figure. I was reluctantly obliged to give them up as polishers, but an attempt was made to utilise them for fine grinding. The face of one of these tools was covered with squares of plate-glass of about $1\frac{1}{2}$ inch side; several hundreds of these were cut, ground to the proper curve, bevelled at the edges, and fastened to the tool with hard pitch. The tool was slightly warmed to soften the pitch, and then pressed on the mirror till intimate contact of all the squares was obtained. The tool was several months in preparation, but a very few minutes' work sufficed to show that it was unworkable. The faces of the glass squares caught the mirror and tore it up in places, but where this had not occurred the surface produced by grinding glass on glass was all that could be desired. The tearing-up of the surface of the mirror was attributed to the slight flexibility of the wood backing,

which allowed a square of glass to spring slightly from the general level, and thus furrow the surface of the mirror.

A similar tool, with round zinc discs $1\frac{1}{2}$ inch in diameter, was made and used, and found to answer much better, since it did not tear up the glass like the other tool, although the surface produced was not so good. Finally this kind of tool was abandoned altogether in favour of the solid glass tool properly grooved.

In these preliminary operations tools of various sizes, made of lead, iron, wood, glass, zinc, marble, slate, and gun-metal were tried, and very much valuable experience and knowledge was gained as to the effect of various strokes in making alterations of figure, the making and management of polishing tools, the proper use of the different kinds of emery according to fineness, and the different polishing materials, and in many minor details, attention to which is so absolutely necessary to accurate work and ultimate success. A full account of the various processes tried and found wanting might be of some interest, but scarcely of sufficient importance to justify its introduction here; and in describing the method of work finally adopted, it is to be understood that in nearly every case the plan followed was the one of several that was found to give the best results for the special purpose in view. In all cases where deviations from the particular plan adopted would appear to offer an advantage, particular reference is made to such deviations, although I may not have been able to adopt them, or may have thought the possible gain not of sufficient importance. In two cases the plan adopted temporarily was found to work so well that the one previously designed was never carried out. The first instance was that iron pipes were used for connecting-rods between the cranks and the tool, and temporary fittings were made for the purpose, which were cheap, easy to use, and so effective that the intended steel tubes with elaborate fittings were never made. The other case was the use of a long wooden lever, with counterpoise weights, which was hung close enough to the mirror to be capable of moving over its centre, so that tools could be picked up and gently swung on to the mirror, or swung off to one side. It was originally intended to construct an overhead travelling lift to carry the tools, but the lever, at first intended for balancing part of the weight of the tool during fine grinding, was found so efficient

that the plan of overhead mechanism was abandoned. It is a great advantage to have no machinery over the mirror, and the lever arrangement is quite capable of lifting 600 or 700 lbs., and enabling tools of this weight to be put on or taken off readily and in a gentle and safe manner. By the use of other levers, moving up near to the sweep of the first, it is quite possible to move a heavy tool anywhere in the workshop, and the arrangement is much more convenient than a travelling crane. With the first disc, as far as the actual working arrangements were concerned, everything was most satisfactory, and the experimental operations of grinding and polishing were carried on, after some experience, with certainty, but the testing showed a peculiarity that has never yet been eliminated. From the very first rough polish, before the surface had been properly ground all over, there was evidence, in testing, of distinct ellipticity in the image. The image of a circular hole at the centre of curvature was not, as it should have been, a circle, but an ellipse, the major axis of which was always in a particular direction across the mirror ; rotating the mirror during the testing caused the axes of the image to rotate also, and in no position was there any improvement in the figure. Dr. Draper found in working mirrors that there was always one position of the speculum that gave best definition and most regular figure ; but this was not found to be the case in testing the 5-foot disc.

Subsequent surfaces obtained on the mirror all showed this ellipticity, but by constant working it was found that up to a certain point each successive surface was somewhat better than the previous one ; photographs of sections of the cone of rays from a pinhole, as reflected back by the mirror, show the ellipticity very clearly, as also the slight improvement effected by working. The ellipticity was looked upon at first with a kind of intelligent interest, as something worth watching before it finally disappeared ; but when it proved itself so obstinate, and was found so persistent, it was regarded with quite a different feeling, and had a most depressing effect upon my hopes.

In shape the image was roughly elliptical, the position-angle of the major axis being about 15° from the vertex of the mirror as placed for use in the telescope. Under a low magnification it was not very pronounced, but with high powers it was very evident, especially with the image slightly out of focus. Efforts were made to correct it by local

polishing, but this only resulted in general irregularity of figure, and gave rise to most extraordinary effects, as could be seen in the testing.

The telescope-mounting had by 1888 been made and erected, and it was decided to re-grind the mirror, polish and figure it without special regard to the elliptical figure, and to try it in the telescope. By the end of the year this was done, and the mirror was found to be much better on stars than had been anticipated; the photographic images of stars did not show any appreciable distortion, although with high powers for visual work the ellipticity was very clearly seen.

At first the ellipticity was attributed solely to the fact that the disc of glass had been standing for four years in an inclined position before it was mounted in its cell. Since then I have thought it most probable that the hole in the centre had something to do with it. In pouring the glass the molten "metal" would necessarily run round the central core of the mould on each side, and join on the opposite side to the stream, producing, perhaps, a weak place in the disc. It may be that a slightly different molecular arrangement exists here, and the glass expands and contracts differently in consequence. There are marks of pouring in the glass, but they do not correspond with the position-angle of the elliptical figure, the position of the glass against the wall being unfortunately not recorded. In consequence of the persistence of this defect a new disc was ordered from Paris in 1888, this time without a central hole, so as to avoid any risk of a weak place. It was delivered at Ealing at the end of 1890, has been ground and polished in 1891, and has proved itself as nearly perfect as one can judge possible, giving a perfectly circular image, both in testing and on stars. There are no pouring marks visible in this disc.

While the new disc was on order the old mirror was taken out of the telescope and re-ground, re-polished, and re-figured, with very slight, if any, improvement in the figure. The working of the second disc, as also of other large mirrors, showed that the same process of grinding and polishing was capable of turning out a perfect mirror; hence I consider that the fault of the first one is in the glass itself. One discovery made during the testing of the second mirror at the centre of curvature throws considerable light upon the matter, and suggests the cause of this fault. After polishing the mirror, it was usual to let it cool off for a considerable time before testing:

usually several hours' rest was given—never less than three hours—during which time the mirror could cool and the image become steady. It was always understood that the focal length was somewhat longer just after polishing than it was when the mirror had reached the normal temperature. I was scarcely prepared, however, to find that the difference was so great. Immediately after two hours' figuring at twenty-three strokes a minute with a 15-inch tool, the resin of which was tolerably hard, and consequently the friction not nearly so much as it might have been, the image of the illuminated grating was found to be 4 inches beyond its normal position. The radius of curvature of the mirror had actually been increased by 2 inches during two hours' figuring. This enormous deformation had to right itself, and really did so with a few hours' rest. It is quite evident that if the glass is not nearly, or quite, homogeneous, it will not expand equally, and therefore unequal abrasion will take place, and the curve produced by the tool on the expanded glass, even if perfectly regular while in the heated state, will not alter symmetrically as the glass cools down to its normal state. If the first disc is—as it possibly is—not quite homogeneous, and expands somewhat unequally when heated, then the difficulties met with are easily explained, but cannot be overcome.

More than two years were spent in making the first mirror, much of the time, however, being taken up by purely experimental work. The number of strokes made by the tools during this time exceeded two millions. The greater part of the period was a time of worry and anxiety; but finally a system of work has been evolved that has enabled me to make the second disc into an almost perfect mirror in three months from the time it was first put on the machine, the whole of the operations of rough and fine grinding, polishing, figuring, silvering, and mounting being performed with confidence and comfort.

In addition to the two 5-foot mirrors, other large ones have been made by a similar method of work. Of these the two mirrors of 20 inches diameter and 45 inches focal length that were used for the Eclipse Expeditions of 1889 December 21–22 were made first, and since then two other similar mirrors, and two of 30 inches diameter and one of 36 inches have been made. In each case the method of work adopted has been found eminently fitted for the purpose, so that there can be little doubt of the

perfect applicability of the method to all mirrors that are of such size as to require machinery.

At one time I thought that an elliptical image from a mirror such as the first disc gives would be very useful for spectroscopic work, and that it might be advantageous to make a mirror sufficiently elliptical to enable spectroscopic work on stars to be carried out without the use of a cylindrical lens, though such a mirror would be useless for ordinary work. Further consideration, however, showed that, by the use of a "flat" mirror with sufficient deviation from perfect flatness, a line could be obtained from a star instead of a point, and I would suggest this plan for obtaining stellar spectra of sufficient width. By changing the flat the telescope could be used for ordinary observations or for photography.

Given a good disc of glass, there would not be any difficulty in making a telescope of much larger aperture than 5 feet: the chief trouble would be in obtaining a disc of sufficient size and fairly homogeneous. We have at the present time reached the limit that ordinary plate-glass makers will undertake, and any increase in the size will mean the erection of a special plant for making the disc.

The mounting adopted for the 5-foot is peculiar, and does not quite fulfil all the conditions suggested in my paper in the *Monthly Notices of the Royal Astronomical Society*, Vol. XLVI.; but it leaves very little to be desired either in steadiness or in cheapness. It is capable of reaching stars of any altitude, and of following them continuously and accurately for eight or ten hours, the only breaks being due to the rewinding of the clock and alteration of driving arc. Of the whole plant the house is the least satisfactory in appearance, though it works very well. Of course it would be an advantage to work under a dome, but one more than 60 feet in diameter would be necessary to cover the telescope and enable all movements to be made independently of it—and this was beyond my means and my available space.

The stage and observing-platform have undergone several alterations and are now fairly satisfactory for manipulation, although they might be greatly improved in the matter of safety and comfort under different circumstances.

It was originally intended to use the mirror as a Cassegrain telescope

(and for this reason a hole was cast in the centre of the disc) till a good plane mirror could be made; but MM. Henry of Paris kindly presented me with a beautiful "flat" of 16 inches diameter, and the telescope was at once mounted as a Newtonian. It has always been used as such, although a convex mirror for use as a Cassegrain may be made for it later on, if this first disc is ever successfully refigured.*

As far as other work has permitted, the making of plane mirrors has also been carried on at Ealing, and several small ones have been made. A 30-inch spherical mirror has been figured and mounted for testing these, on the plan proposed by me in the *Monthly Notices of the Royal Astronomical Society*, Vol. XLVIII. p. 105.

With this introduction I can proceed to give a full description of the machine and tools and of the method of testing the mirror, together with a description of the telescope-mounting and house.

For convenience, I will divide the description into sections as follows:—

1. Arrangement of Workshops.
2. Grinding Machine.
3. Tools.
4. Grinding and Polishing.
5. Figuring and Testing.
6. Silvering.
7. Mounting of Mirrors.
8. Telescope Mounting.
9. Accessories.
10. House.
11. General Remarks.

* Further attempts made to refigure the first disc not succeeding, the makers have very kindly undertaken to take it back and replace it by another. This will not have a hole through the centre, and so will not be available as a Cassegrain telescope.

I.

Arrangements for the Workshop.

The grinding-room is built of wood and corrugated iron, against the south wall of the workshop. The floor is made of cement, and is so arranged that there is a fall towards one corner; the whole floor thus acts as a large sink, and the room can be thoroughly flushed with water, and the coarse emery, &c., washed away before fine grinding and polishing are attempted. The room is lighted by a skylight extending the whole length of the roof, canvas being fixed under the skylight so as to guard against dust, &c., that may blow in. The large grinding machine is arranged on the east side of the house, and a wide double door is made on the south side close to the machine, so that, when the mirror is inclined and the doors open, the testing of the surface by Foucault's method can be readily carried out from the separate testing-house, which stands facing the mirror at a distance of about 57 feet. This testing-house is somewhat like a sentry-box, about 5 feet square, with a floor about 6 feet from the ground-level. A hole is provided in the side facing the mirror, and a table to hold the apparatus and a chair for the observer complete the arrangement.

The space available for a grinding-room was limited, and the house has always had the fault of being too small; there is not sufficient room all round the machine for the free handling of the tools or for the proper arrangements of levers for lifting them. There is, however, plenty of room for the machine to perform its necessary work without hindrance of any kind, and the small size of the room has only been a matter of extra personal trouble.

The general arrangement of the engine-room, workshops, and grinding-room can be easily made out from the block plan. The original building was the workshop, and is built of brick; on its eastern side a brick transit-house was then added, and that was the condition of things when, in 1885,

I determined to grind the 5-foot mirror. The grinding-room was then erected against the south side of the workshop, the machines were placed in position, an engine-house built against the north side of the workshop, and shafting put in to transfer the motion from the gas-engine in the engine-room to the grinding machines. For experiments in electric lighting, a $2\frac{1}{2}$-horse power gas-engine had been in use in the old workshop; but this was replaced by one of $\frac{1}{2}$-horse power nominal, as likely to make less vibration, and it was placed as far as possible from the grinding machine.

Experience has shown that this grinding-shop has many excellent

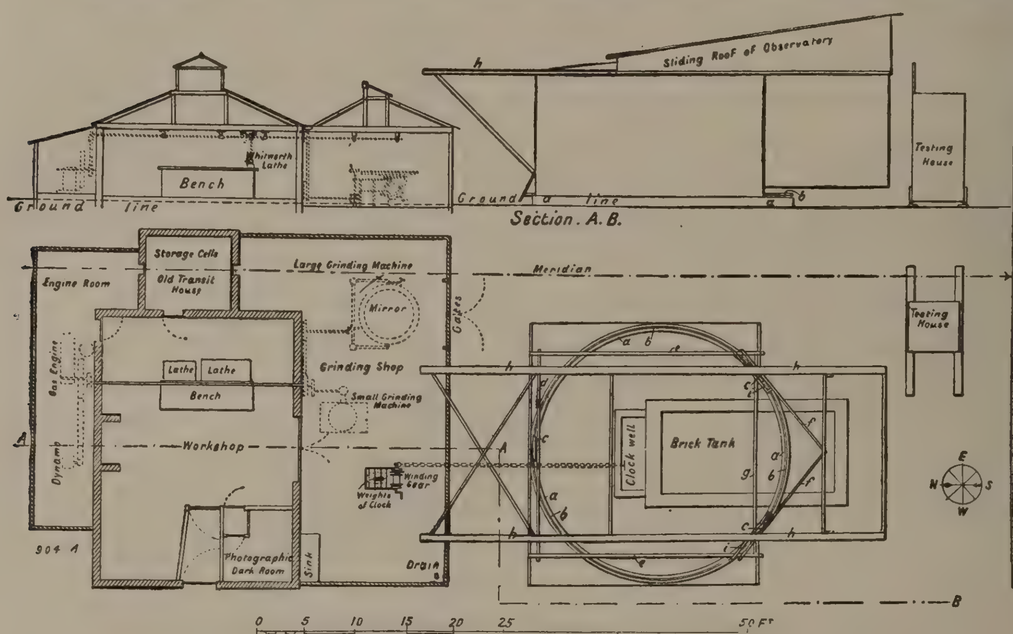


Fig. 1.

points, and testing in the open air has avoided the long and expensive building otherwise needed. The iron construction is good, as the temperature is not very different inside and out; and the whole floor, being of concrete, can be easily washed down or kept damp during polishing and during the process of silvering a large mirror. The use of plenty of water in working is quite easy, for when the mirror is tipped up the water simply runs away without further trouble.

Fig. 1 shows the plan of the grinding-shop and workshops, and also includes the essential features of the plan of the observatory or telescope

house. A sectional elevation of the workshop and a side elevation of the observatory are also given.

The positions of the lathes and bench in the workshop and of the photographic dark room with its double doors are indicated by strong lines, while dotted lines show the positions of the gas-engine, dynamo, and the two grinding machines. The floor of the grinding-shop is laid with concrete and cement, falling away in all parts towards the south-west corner, where the drain is situated. The weights of the driving clock of the 5-foot telescope are shown in the grinding-shop, together with the winding gear for the clock. In front of the large grinding machine are the double doors, or gates which, when fully open, enable the testing of the mirror to be carried out from the testing-house, that lies to the south of the workshop. The old transit-house is used for storage-cells since the alterations closed up the shutters. The meridian mark on the fence served to lay out the north and south line, so that the brick tank of the telescope could be built with its walls parallel to the meridian line of the transit instrument.

The brick tank shown in plan in this fig. is seen in section in fig. 43, so that details of it and the clock well can be easily obtained by measurement of the drawings.

In the plan of the observatory *a* is the circular brick curb carrying the rail ; *b* is the circular rail ; *c c c* are the wheels resting on the rail *b*, on which the house rotates ; *d*, *e*, and *f* are beams of wood supported on the wheels *c c c*, and forming the base of the framework of the house ; *g* is a cross beam bracing the framework ; while *h h* are the two upper beams (shown in elevation also) which carry the rails of the sliding roof ; *i i* are additional beams attached to *f f* so as to embrace the wheels *c c* and secure them properly to *f f*.

II.

The Grinding Machine.

In planning the grinding machine a careful study of previous machines, as described by Rosse, Draper, and others, showed that a slow rotation of the mirror was usual, and that a tangent screw had nearly always been used for giving this slow motion. Following precedent in this respect, I arranged

for the mirror to be driven by a tangent screw and wheel ; but, as it seemed to me that driving by belts would offer many advantages, I provided for that also, and arranged for driving pulleys to be fixed on the shaft of the west crank, while the cell of the mirror was made so that it would act as the driven pulley, and the required rotation be thus easily given. By alteration of the size of the pulley various speeds of rotation could be obtained without trouble and without alteration of the number of strokes per minute, and arrangements easily made for a long period of time to elapse between two identical strokes of the tool by making the driving pulley somewhat *less* than the diameter of the driven pulley divided by a whole number, such as 5, 7, or 9.

The tangent-screw method was tried, but was far less satisfactory than the belt driving. The action of the tool being sometimes with and sometimes against the direction of rotation of the mirror, this, with the slight backlash of the tangent screw, caused a jar with each stroke that was unpleasant and unsatisfactory ; the belt driving prevents this shaking, and, being more regular, is much more likely to give the required accuracy of optical figure. After the first trial of the tangent gear it was abandoned, and belt driving has always been used.

Essentially, the machine consists of two strong brackets firmly fixed on to the stone blocks in the floor of the grinding-room, and carrying between them a strong cradle supported at each end on one of the brackets by bearings that allow the cradle to be turned through an angle of 90°, so as to enable the mirror to be optically tested. The plan shows the two brackets held together firmly on their north sides by means of angle iron, and carrying the cradle on which the mirror and cell are resting on bearings in their southern ends. The cranks on the lower portion of the plan are carried on two vertical shafts, which are driven from a horizontal one by mitre wheels. Provision is made for changing the mitre wheels of one from the top of the shaft to the bottom : but this has not been found necessary. The wheels are usually placed so that both shafts rotate in the same direction, but, by simply lifting up the west shaft, any part of the mitre wheel on it can be engaged in the mitre wheel on the horizontal shaft, so that the tool can be made to be pulled on the edge of the mirror by the west crank when at the extreme throw from the east crank, or the greatest motion from the west crank can be given when the east crank has pulled the tool into the

centre of the mirror. This arrangement of wheels also allows the tool, when on the edge of the mirror, to be pulled in the direction of rotation of the mirror, or pushed in the contrary direction. A perfect control is thus obtained over the amount of abrasion allowed at any part of the mirror, and most work can be done at the edge or the centre as desired.

From the plan, fig. 2, it will be seen that the cranks at the tops of the vertical shafts are of different lengths. By varying the lengths of these cranks any length of stroke can be easily obtained.

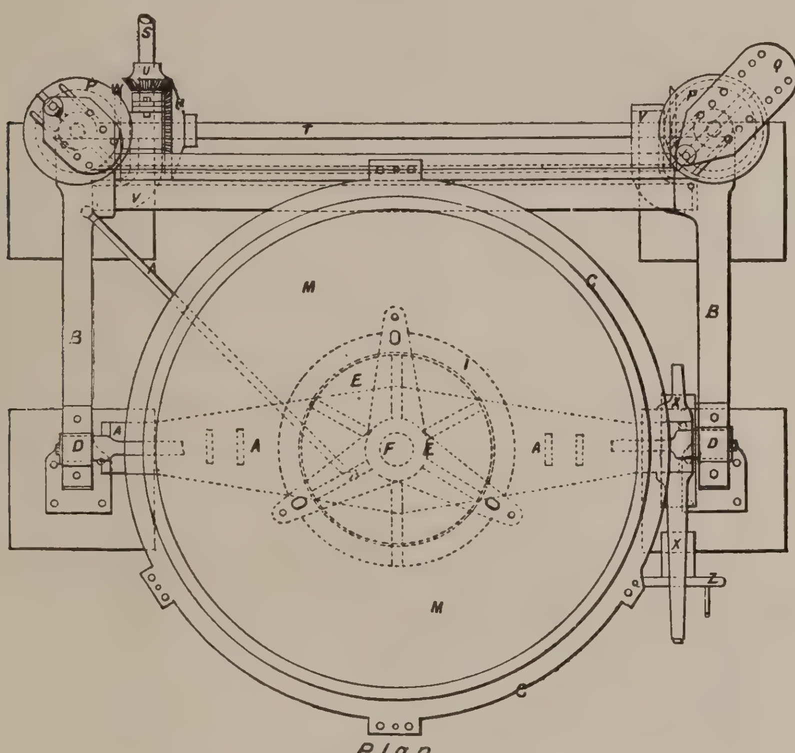


FIG. 2.—Scale $\frac{1}{2}$ inch to 1 foot.

The rate at which the machine is driven is about twenty-five revolutions of the vertical shaft per minute, the rate for the mirror being nearly five or nearly eleven, according to the size of pulley used. The driving pulleys are one of 12 inches diameter and one of $5\frac{1}{2}$ inches, and either of these is used according to the kind of stroke required, although the 12-inch one has been found most useful.

When the machine was devised it was arranged for use on other mirrors smaller than 5 feet, and the turn-table was arranged to carry the cell of the 5-foot mirror direct, or to be used with a 3-foot plate attached, on which the

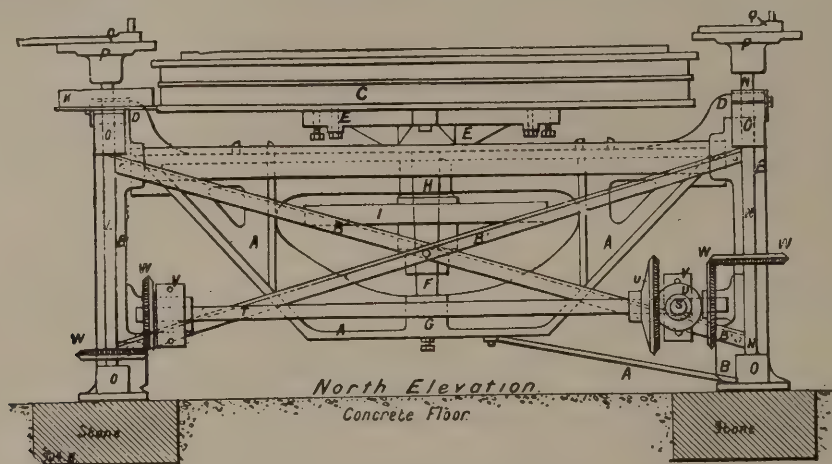


Fig. 3.—Scale $\frac{1}{2}$ inch to 1 foot.

smaller mirrors could be fixed. The 3-foot plate is made so as to act as a pulley, and then the $5\frac{1}{2}$-inch pulley is most efficient for grinding and figuring.

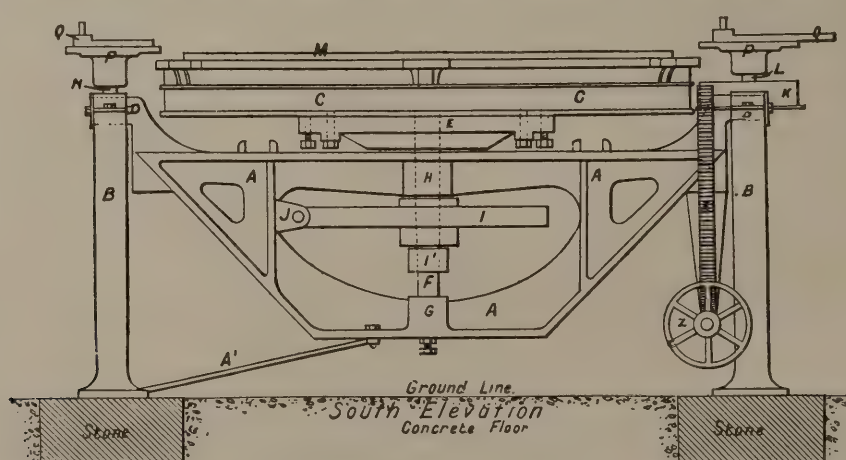


Fig. 4.—Scale $\frac{1}{2}$ inch to 1 foot.

Fig. 2 is the plan of the grinding machine, and figs. 3, 4, 5, and 6 are the elevations from the north, south, east, and west; fig. 7 shows the rods and their attachments, while fig. 7A is an enlarged section of the bottom of shaft

carrying mirror table. Similar lettering is adopted to indicate the same parts of the machine in the different drawings.

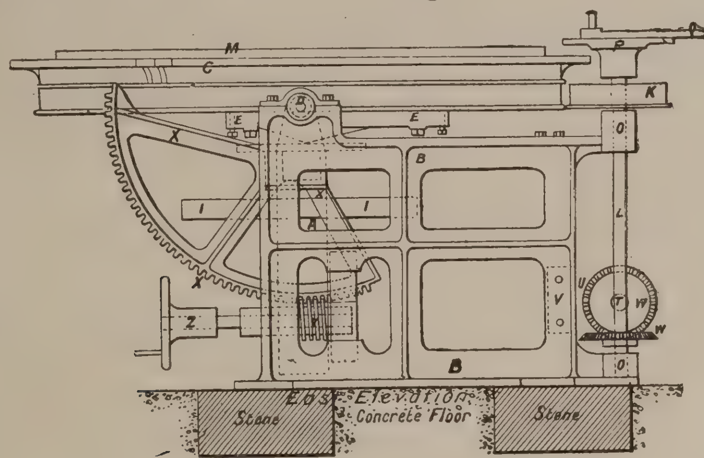


FIG. 5.—Scale $\frac{1}{2}$ inch to 1 foot.

M is the mirror in this as in all the other drawings. C is the cell.

A is the cradle, or strong iron framework, that forms the essential support of the mirror.

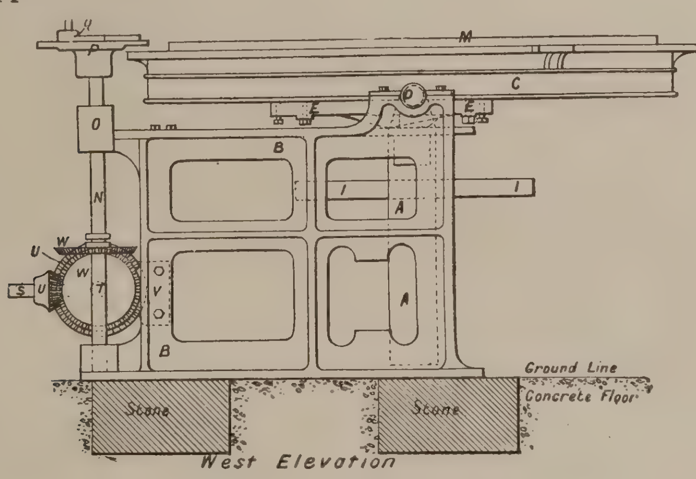


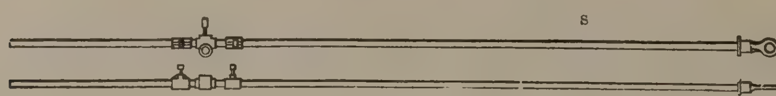
FIG. 6.—Scale $\frac{1}{2}$ inch to 1 foot.

B B are two strong brackets firmly bolted down to the stone blocks set in the concrete floor. These are braced together on their northern side by 2-inch angle iron B′, and near their southern edges have two bearings D, into which the ends of A are fitted.

D are the bearings of A in B, these bearings being covered by plates firmly bolted to B.

E is the turn-table of the machine, and to it the cell C of the mirror is firmly bolted. The plan shows two sets of holes in the arms of E. The slotted holes are for the fixing bolts, and the round ones for set screws for levelling the mirror and cell when on the machine.

F is the steel axis of the turn-table.



Scale $\frac{1}{2}$ inch to 1 foot.

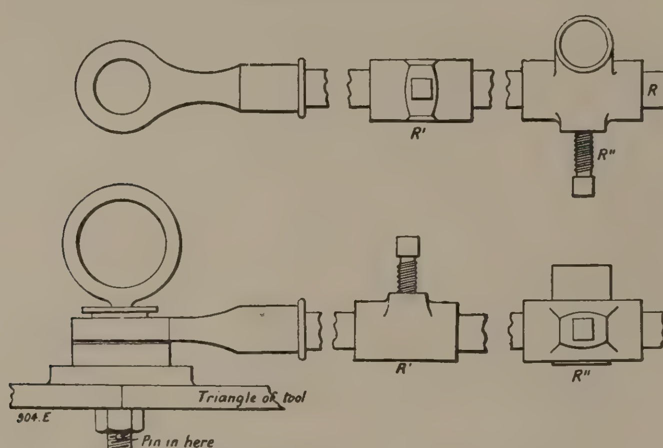


Fig. 7.—Scale $\frac{1}{4}$ full size, or 3 inches to 1 foot.

G is the bearing of this axis on the lower portion of the cradle A. An enlarged view of the section of G is shown in fig. *7a*.

H is the upper bearing of the axis F in the cradle A.

I is a toothed tangent wheel keyed on to the axis F, and held in position by the collar I′.

J is the bearing on which the tangent screw gearing with the wheel I is fixed. In the drawings this screw is not shown, the rotation of the mirror being brought about by means of

K, the pulley on the shaft L, or east vertical shaft.

L is the east vertical shaft.

N is the west vertical shaft.

O O are the bearings of the vertical shafts L and N in the brackets B B.

P P are circular plates (east and west) keyed to the shafts L and N. The slotting shown in the plan enables the cranks

Q Q to be altered in position by means of bolts that pass through the slots into the cranks. By altering the positions of these cranks the amount of "throw," or stroke, given to the tool from the east or west side can be varied from *nil* to over 2 feet 6 inches.

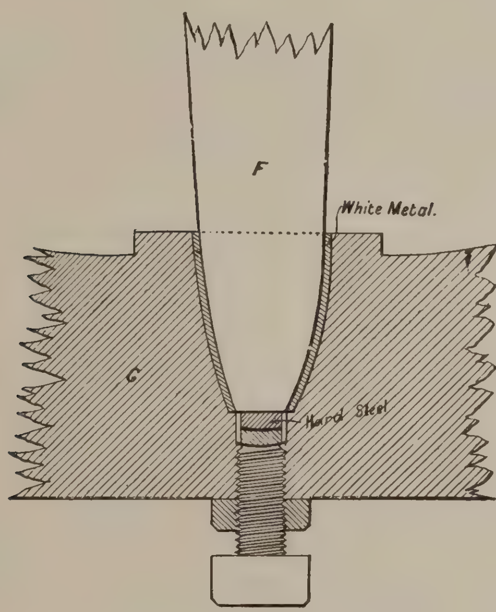


Fig. 7*a*.—Scale 3 inches to 1 foot.

S is the main shaft of the machine, by means of which the power of the gas-engine is communicated.

T is the horizontal shaft at the northern side of the machine, this shaft being rotated by means of the mitre wheels U U.

V are the bearing-pieces for this shaft, these being firmly bolted on to the brackets B B.

W W are mitre wheels on the shaft T and on the vertical shafts L and N, to communicate the motion of the horizontal shaft T to the two vertical shafts. These shafts rotating rotate the cranks, and the rods (R, shown in fig. 7) carry the motion to the tool on the mirror.

X is a sector attached to the east side of the cradle A.

Y is a tangent screw fixed to the east bracket B and gearing with the sector X.

Z is the handle on the shaft of the screw Y; by means of this the cradle A, and with it the mirror (M), can be turned up into a vertical position.

A′ is a rod from the west bracket B to the base of the cradle A. By means of a bolt through the base of A into A′ the cradle is firmly fixed so that the mirror is perfectly levelled and centred. When this bolt is removed, the cradle and mirror can be turned up for testing the mirror; and, at the close of the operation of testing the mirror, can be levelled again with absolute certainty by replacing the bolt.

The connections of the cranks to the tools were intended to be elaborate steel bars with slotted pieces for lengthening, &c., but ordinary $\frac{3}{4}$-inch iron barrel-pipe was used temporarily, with brass fittings, as shown in the drawing, fig. 7; and these have been found to perform excellently, so that the steel rods were never made.

One end of the iron pipe is fitted with a brass ring, or eye, which loosely fits the pin at the back of the tool; on to the other end of the barrel a sliding tube of brass is passed, with a setting screw through it, so that it can be fixed at any part of the gas-barrel. This acts as a safety-guard.

After this comes the crank attachment, which is another sliding fitting, consisting of the tube through which the gas-barrel slides, and in which it can be fixed with a setting screw, and, in addition, another tube, at right angles to the first, fitting on the pin of the crank. After this another safety-guard is put on, similar to that previously described. The rotation of the crank carries the crank attachment with it, and this being firmly fixed to the rod by the setting screw, the motion of the crank is communicated through the rod to the tool. The safety-catches are fixed one in front and one behind the crank attachment, so that if by any means the rod becomes loose in that, the movement of the crank will not push the tool off the mirror. An examination of the drawings will show at once the method of attachment, two views of the rod and attachments being given. The safety-guards may be used as

the limiting guides to indicate the various alterations that are to be made in the length of the rods, and consequently of the position of the centre of the tool on the mirror during a period of figuring, and are very useful in this respect in the actual use of the machine. Excepting in the coarse grinding, it has always been a standing order that no setting of the cranks shall be used for more than ten minutes; in polishing and figuring one of the cranks or rods is moved every five minutes. This is the most certain and effective method of preventing rings appearing on the final surface. It is easily seen that this machine is quite capable of enlargement or reduction in size.

Fig. 7 shows the rod and the rod attachments, and is perhaps sufficiently clear to explain itself. The rods are shown on the same scale as the machine in figs. 2, 3, 4, 5, and 6—*i.e.* $\frac{1}{2}$-inch to the foot, while the separate attachments are shown 3 inches to the foot. The "eye" at the end of the rod fits on to the central pin of the tool. The slipping piece R′ fits on to the rod, and can be fixed on any portion of it by means of the set screw.

The crank attachment R″ fits on to the pin of the cranks Q (see fig. 3), and can be firmly fixed to any portion of the rod R by the set screw; the distance between the "eye" and the crank attachment R″ can be thus varied to any extent according to the size of the mirror and the portion of it on which it is desired to work most. Another slipping piece similar to R′ fits on the rod below R″, and serves not only as a safety-guard, but also, with the one between R″ and the "eye," as a means of regulating the amount of alteration of rod made during a given period of work.

As an example of the various strokes which the machine is capable of giving, the diagrams made on the machine are given, the line showing the travel of the centre of the tool on the mirror.

Figs. 8, 9, 10, 11, 12, and 13 are sample diagrams of curves made with the grinding machine. The blocks are exact copies and are of the same size as the original curves. It will be seen from the firmness of the lines and the even nature of the curves that after some four millions of strokes the amount of wear on all the bearings is scarcely perceptible.

The method of obtaining the curves is to place a sheet of smoked glass $3\frac{1}{4}$ inches square in the centre of the turn-table, to fasten a steel point to the intersection of the two rods from the cranks (the steel point being in the position the centre of the tool would occupy), and then, having set the cranks and rods to some stroke which has been or could be used, to start the machine and allow the steel point to scratch the smoked surface of the glass. Figs. 8, 9, 10, and 11 were obtained with the small pulley driving the turn-table, and in these the steel point was allowed to scratch the smoked surface during three complete revolutions.

In fig. 8 only one crank is working, and the rod is pushed out so that

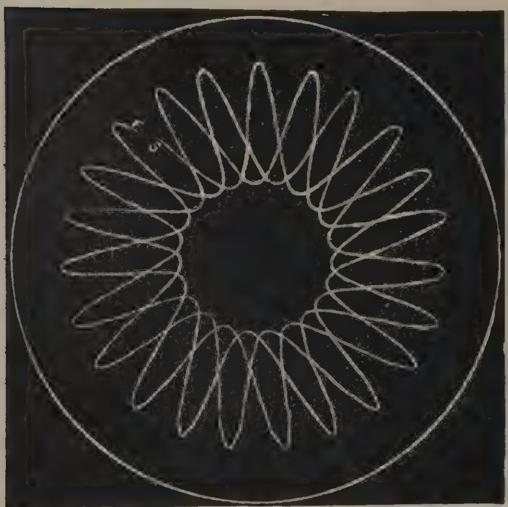


Fig. 8.

Fig. 9.

the centre of the tool never reaches the centre of the mirror. By altering the length of the rod and the length of throw on the crank it is seen the amount of work done on the edge or on the centre of the mirror can be regulated at will. In fig. 9 the rod is not pushed out, and the throw on the crank is increased so that the centre of the tool is allowed to pass over the centre of the mirror. It is obvious that this stroke cuts more at the centre than at the edge, and when an increase of aberration is required by deepening the centre, this stroke is resorted to.

A somewhat similar stroke with both cranks working is shown in fig. 10.

Fig. 11 is a setting which is found most effective for working on a definite zone of the mirror, and is obtained by pushing one rod out and altering the mitre wheel of west shaft as described on page 126, *ante*.

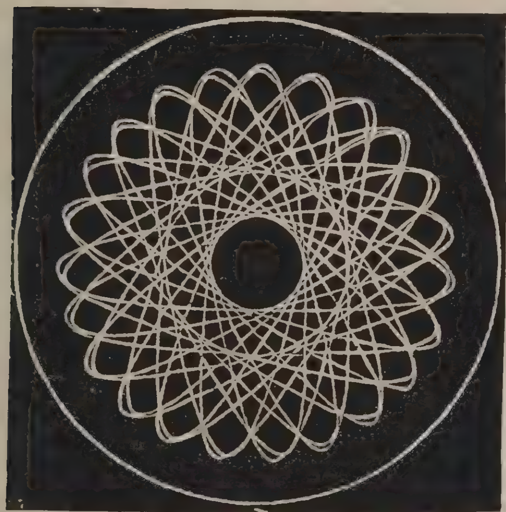


FIG. 10.

FIG. 11.

FIG. 12.

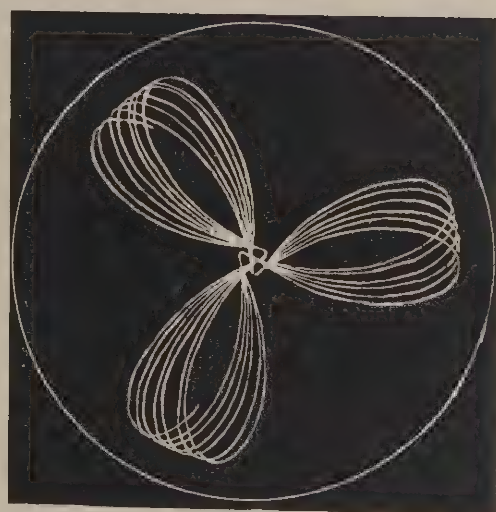


FIG. 13.

Figs. 12 and 13 show the effect of a bad arrangement of the driving pulley and turn-table. For the 5-foot mirror a large pulley (12 inches diameter) is used, but with the 3-foot turn-table a small pulley ($5\frac{1}{2}$ inches

diameter) is provided. In order to hasten the grinding of the 36-inch mirror the large pulley was used with the 3-foot turn-table, and this happens to give a proportion of nearly three strokes of the cranks to one revolution of the turn-table. There was, therefore, a tendency to produce a mirror giving a triangular image, and in polishing this speedily became apparent, even when the utmost care was taken to complete the number of revolutions so as to bring the tool back to its exact starting point. The smaller the tool used the more prominent this defect was, and it was found absolutely necessary to use the small pulley.

III.

Tools.

My experience has shown that to get the best results in the least time four kinds of tools are necessary. First, a rough piece of hard lead for grinding with coarse emery, to cut away the glass to form the concavity. With the 5-foot disc a large quantity of glass had to be ground away, a depth of 0·6 inch being necessary in the centre of the concavity, and to roughly obtain this the lead tool was used. This tool may be of any size from one-half to one-quarter of the diameter of the mirror, and from 2 to 4 inches thick; a strong triangle cast into the tool and carrying a pin serves for attachment for the rods and for lifting the tool. It is advantageous to have the tool cast with a number of $\frac{3}{4}$-inch holes in it, through which the emery or sand used in coarse grinding can be fed on to the mirror, and the necessary water also readily added from time to time. The lead tool used was 22 inches in diameter and 4 inches thick, had nineteen holes in it, and weighed altogether, before use, over 400 lbs. It was roughly chipped underneath from time to time during grinding, and was found to cut very rapidly with No. 12 emery.

The second kind of tool is a convex iron tool, or rather a pair of iron tools, with a diameter of not less than two-thirds of the diameter of the mirror, although probably full size would be best. This convex tool is exceedingly important, as with it the fine grinding is carried on down to the use of No. 150 emery, or even finer, and it is this tool that not only gives the exact curve

necessary, but also secures the accurate surface of revolution. It will be seen from fig. 14 that in this case I have adopted a plan which I consider essential for all tools—all the points of attachment for lifting or turning the tool on the lathe or driving the tool when on the mirror being reduced to three points. The system of ribs is concentrated on three points, and to these the triangle carrying the driving pin is attached. Lifting is performed by means of an eye screwed into the driving pin. When not in use the iron tools are always arranged face upwards, with three blocks under them, one at each of the points where the ribs unite. In the case of the first large wooden tools six points of support or attachment were used, by a cross-piece at the end of each of the three arms, and it might be necessary to use this number, or more, with very large iron tools ; but for any size up to 40 inches the three points of attachment are quite sufficient. The three points are approximately the centres of gravity of the three sections into which the tool may be considered to be divided. With the iron tools the deep ribs at the back shown in the drawing were considered necessary to secure the essential rigidity and permanence of shape.

The convex iron tool is cast with a face of squares of 1-inch side with $\frac{3}{8}$-inch spaces between, the great essential being that the exact centre of the tool must fall on one corner of and not in the middle of a square. The attachment to the face-plate of a lathe is by screws which screw into the three points in the ribs, and the face of the tool is then accurately turned to the proper convex curve from a previously constructed templet with the least danger of change in figure when taken off the lathe.

Another tool is cast, strengthened by ribs in a manner exactly similar to the first, but without the squares on the face ; this tool is turned concave in the lathe to as nearly as possible the curve required for the mirror. Considerable accuracy can thus be obtained, but the most careful mechanical turning is not nearly accurate enough for optical work. The pair of tools must therefore be ground together with fine emery (Nos. 100 to 150 emery are usually employed for this operation) until they are perfect surfaces of revolution, and until by the spherometer they are found to be of the exact curve required. There is no difficulty in grinding two iron tools of this kind together with the finest emery, if one of the surfaces is covered with squares in the manner adopted for the convex tool ; without this precaution

it is difficult to prevent the two surfaces gripping and tearing each other, and it is impossible to obtain the absolutely spherical surface of revolution. With the convex tool uppermost, the tendency is to flatten the curve and to increase the radius of curvature; with the concave tool uppermost, the curve is deepened and the radius of curvature shortened. By this means, and by a careful regulation of the strokes in grinding any required curve can be obtained, with an exactness that is truly astonishing. The concave tool not only serves for the purpose of bringing the convex tool to the proper curve, but also to give form to the glass and slate tools for fine grinding and for polishing. It may also be used instead of the mirror for pressing the polishing tools when covered with resin squares, so as to give them the proper curve.

These iron tools are the most important ones in making mirrors, and no trouble should be spared to make them as perfect as possible.

Fig. 14.

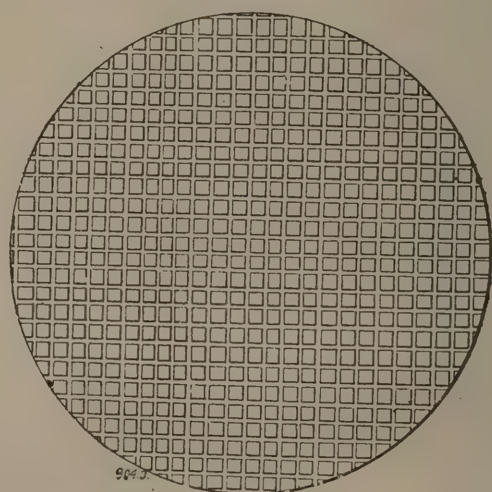


Fig. 16.

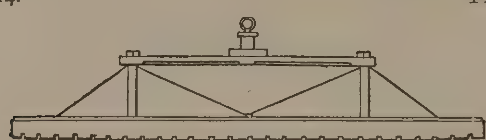


Fig. 15.

Fig. 14 is a plan of the back of the 40-inch convex iron grinding tool, showing the system of ribs and the attachment of the triangle. The ribs all concentrate at three columns, to which the ends of the

triangle are bolted. The centre of the triangle is the pin on to which the "eyes" of the rods R are attached.

Fig. 15 is a side elevation of the tool shown in fig. 14, and shows the ribs and the method of attachment of the triangle.

Fig. 16 shows the squared face of the tool, the centre of the tool falling on one corner of a square.

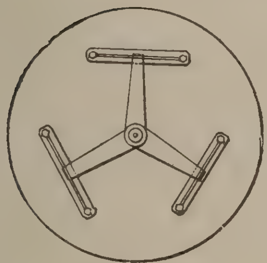


Fig. 17.

Fig. 18.

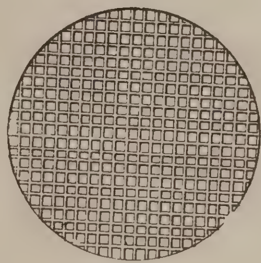


Fig. 19.

Figs. 17, 18, and 19 are drawings, on the same scale, of the 23-inch glass tool, the triangle being fixed to the back of the tool by six bolts passing through countersunk holes in the face of the tool, and held firmly in place by nuts screwed on to the ends projecting through the three levers. The glass tool is fixed to three levers, and the three arms of the triangle are attached to the centres of these.

By means of the heavy lead tool the mirror can be ground very nearly to the proper curve, so that little or no variation of shape of the tool should be caused when the iron convex tool is used on the mirror. If any variation of the curve of the iron tool should be produced by grinding, then the concave and convex iron tools must be ground together until the exact curve is obtained, and the convex iron tool again used on the mirror. This must be continued until the mirror has a curve exactly similar to that on the concave iron. These precautions are only of importance when it is necessary to keep to a definite focal length, the effect of the slight variation in the curve of the face of the iron tool being simply to shorten or lengthen the focal length, and not to affect the mirror in any other manner.

The third kind of tool used is made of glass, and may be from $\frac{1}{4}$ to $\frac{1}{3}$ of the diameter of the mirror. An iron tool, with half its weight balanced by means of a lever, may be used on the mirror with flour emery, but for

finest washed flour emery the glass tool is best, the surfaces produced being of great smoothness.

Very much time is saved in the operation of polishing by the use of the glass tool in fine grinding, the surface produced by glass on glass with the finest washed flour emery being very much more readily brought to a perfect polish than any other ground surface that can be obtained.

For this tool I used a disc of glass 23 inches diameter and 2 inches thick, and attached to a triangle in the manner shown in figs. 17 and 18, and ground on the concave iron tool with emery and water until it had the exact curve of the convex tool. The surface, previously roughly squared, was then again squared by means of grooves cut into the face. This grooving is easily performed by the use of an iron casting, with six V-shaped bars spaced 1 inch apart; this, driven with a reciprocating motion between guides over the face of the tool, with sand, corundum, or emery for grinding material, and with water as a lubricant, cuts the grooves very quickly to the required depth. The grooves in the 23-inch glass tool are $\frac{1}{4}$ inch wide and of about the same depth; the squares are therefore $\frac{3}{4}$ inch at the sides, with $\frac{1}{4}$-inch spaces between.

The grooves are arranged as in the iron tool, so that the centre of the tool falls exactly on the corner of a square. Opinions differ as to the necessity of these grooves, but I have not the slightest doubt that they are essential to the proper production of the finest surfaces, whether curved or flat. With the grooves there is less tendency to seize than without them—indeed, without the grooves, even with the utmost care in feeding the emery on to the mirror, it is almost impossible to prevent tearing of the surface. The emery is also much more evenly distributed under the tool, since it can penetrate the grooves and thus get under the squares, whereas without the grooves the fresh emery is caught by the edge of the tool, and there is more work done by that than by the central portion.

The glass tool is not used to produce any alteration of shape in the mirror, it is only for smoothing up the surface to save time in polishing; but by working more on one part than the other, an effect similar to that of figuring with the polishing tool can be obtained.

With the glass grinding tools for fine grinding, and with the polishing tools of glass, lead, or slate, the arms of the connecting pin are made

to the proper length to reach the centres of the sections, and the tool is attached to these arms by bolts through the disc, and through holes in the arms. An equally good fastening could be made, in the case of glass tools, by drilling and tapping the hole with a Whitworth thread, exactly as if the tool were cast iron. The drilling and tapping of glass is quite easy if turpentine is used as a lubricant, the only difficulty being to prevent the chipping of the glass when the drill comes through at the end of the operation of drilling.

The fourth kind of tools are the polishers, which serve not only for polishing, but are also used for figuring the mirror. These may be of lead, slate, or glass, with a smooth face ground to the curve of the mirror in the iron concave tool, and covered on this face with squares of pitch or resin. Three of these polishers are required : a large one half the diameter of the mirror—this polishes very quickly ; one about a quarter, and another somewhat less in diameter. These tools are attached to triangles, exactly as the glass grinding tool is attached to its triangle.

Either pitch or resin can be used for the squares on the surface of the tool, but I give the preference to resin, as being cleaner and more easily worked. The squares are made of 1-inch side, and are fixed to the tool $\frac{1}{2}$ inch apart. The resin squares are made very easily in the following manner :—The resin is melted in a clean iron pan and softened by the addition of turpentine until, when cooled to the temperature of the workshop, it will allow the thumb-nail to make an impression in five seconds with a fair amount of pressure. It is almost impossible to give any definite idea of the proper hardness of the resin to produce the best results, or to refer it to any scale : a few trials will soon enable the proper degree of hardness to be estimated, and I would recommend that in the first trials the temperature of the workshop should be noted and the tool used for polishing for three hours ; at the end of that time the squares should be flattened out, and their edges should overhang the spaces between the grooves a little. The softer the resin the more quickly the polisher will work and the flatter the squares will become. If, after three hours' work, the resin is of the hardness that I have found most convenient, the edges of the squares will overhang sufficiently to render it necessary to chip them off to keep the grooves open. If this flattening is sufficient to render chipping necessary

after two hours' work the resin is too soft. A tool that will stand three hours' work without the grooves closing up can be hung up face downwards for several weeks without the resin altering in shape, unless there is a great increase of temperature in the interval. This hardness, when once obtained and tested with the thumb-nail, can always be recognised.

The squares are best made by pouring out the resin on a plate of wet ground plate-glass, with a frame of wet wood round it to retain the fluid resin until cool. The layer of resin should be $\frac{1}{4}$ inch thick. As the resin cools, and before it becomes hard, the wood frame may be removed, and the resin can then be marked out by pressing a frame of wet wood upon it, the frame used being similar to the iron frame used for grooving the glass tools. The frame first marks the resin out into strips 1 inch wide, and by pressing the same frame again on the resin at right angles to the first impression the squares are obtained. The resin thus indented to the depth of $\frac{1}{8}$ inch will easily break, when cold, into squares, which should be immediately placed in water and kept there until they are mounted on the tool.

The resin squares can be firmly attached to the tool by first warming the tool with a Bunsen's burner, then successively warming each resin square and gently pressing it upon the previously marked tool. In using a tool of smaller size than the mirror, the exact position of the central square may not be of much consequence, but, as a matter of habit, we have always put the squares on in a manner exactly similar to that used for the squares on the iron and glass grinding tools. The tool, with the squares attached, should then be hung face downwards and immersed in hot water for half a minute ; then pressed upon the concave iron tool, or upon the mirror ; a piece of rouged paper being used with the iron tool so as to prevent any grit being taken up in the resin, but if the mirror is used, the surface should be first covered with a thin coat of rouge and water, to prevent adhesion.

After the first pressing it will probably be found that all the squares have not made good contact ; a second warming in hot water for half a minute, and a second pressing upon the tool or mirror should bring all the squares into contact. The tool should then be cooled by running cold water over it, and ought not to be used for at least six hours. If the mirror be used for pressing the tool, it is always advisable to allow the tool and

mirror to stand at least twelve hours after pressing before commencing polishing.

The dimensions of the tools used in making the last 5-foot mirror are as under :—

Lead rough-grinding tool (weight about 400 lbs.)
Iron tool, 40 in. diameter (weight about 500 lbs.)
Similar tool, concave (weight about 350 lbs.)
Glass fine grinding tool, 23 in. diameter.
Large slate polisher, 30 in. diameter.
Small „ „ 16 in. diameter.
Small lead polisher, 15 in. diameter.

In order to turn the tools to the exact curve two templets were made. A long bar, 57·4 feet long, was made and fastened by a pin at one end ; this was supported on rollers so as to be capable of rotation round the pin ; two sheets of zinc were laid under the free end and marked out with arcs of a circle of this radius ; these plates were then cut through along the line and accurately filed up to the curve, one as a convex and the other as a concave templet. A third zinc templet was made by commencing at the centre and setting off at short intervals the versed sines of the curve from the edge, previously made straight, and then cutting to these points and smoothing the curve. This is the easiest plan, and, when the measurements are carefully made, better than the radial bar for such a long radius.

From the zinc templets iron ones were made, $\frac{1}{4}$ inch thick, 5 feet long, and 3 inches wide, and these were used in the lathe as guides for the turning tool. The templets are useful for roughly testing the curve of the mirror or of the convex iron and glass grinding tools during the early stages of grinding, but for more accurate work, and during the final grinding, two spherometers were used for measuring the curve.

One spherometer is of the ordinary form, with three legs, on a circle of 3 inches radius or 6 inches diameter, and a central leg, which can be raised or depressed by means of a screw of 40 threads to the inch. The head of the screw carries a circle of 3 inches diameter, divided into 250 parts, and a fixed index is attached to the frame of the spherometer ; one turn of the

screw alters the leg $\frac{1}{40}$ inch, and one division on the divided circle corresponds to $\frac{1}{10000}$ inch. In practice it was found that a movement of a quarter of a division could be detected with the spherometer and $\frac{1}{40000}$ inch accurately measured.

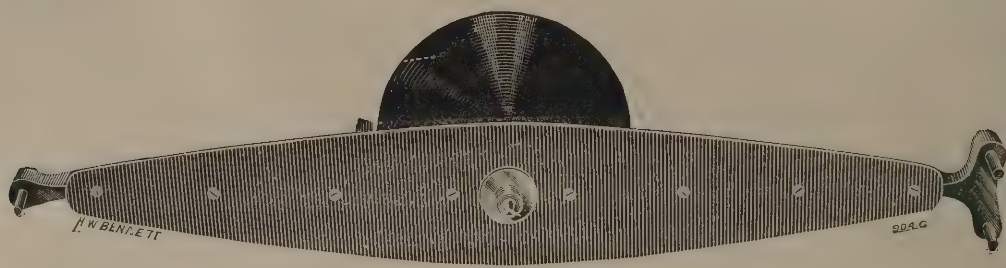


Fig. 20.

The other spherometer has three feet on a circle of 12 inches diameter, but two of the feet are placed close together—in fact, but 1 inch apart; the depth of a curve is thus measured more readily on squared tools than with an ordinary spherometer, and the instrument is practically a versed-sine measurer. (See figs. 20 and 21.)

With these spherometers the departure in curvature of a parabolic mirror of short focus from the spherical form could be very easily detected—indeed, a fairly approximate measure of the amount of parabolisation could be made without optical testing.

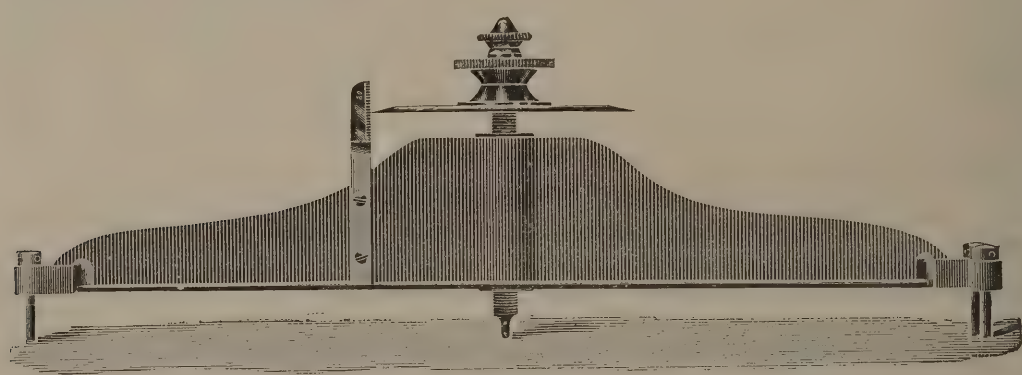


Fig. 21.

It is exceedingly important with these spherometers—especially with the long one—to avoid handling the arms of the spherometer in any way during the actual measuring of the curvature. As an experiment, a

spherometer was made just "loose" on a mirror, the instrument lifted gently, and one arm held in the hand for half a minute; the spherometer was then placed again on the mirror on the same portion as before, and, although the screw had not been touched and the reading was unaltered, the rise of temperature had been sufficient to cause the spherometer to be very "tight," and it was only after allowing the instrument to cool that the original reading could be made.

The custom is to have the measuring screw in the centre of the ordinary spherometer: and that is, no doubt, a convenient place; but if placed on one of the outer legs the accuracy of the instrument is at once doubled and the errors of the screw halved.

IV.

Grinding and Polishing.

The method adopted in making the second 5-foot mirror embodies the results of all the experimental work on the first 5-foot, the two 20-inch mirrors of 45-inch focus (used by the Total Solar Eclipse Expeditions of 1889, December), and also two 30-inch mirrors and a very fine 36-inch.

A full description of this method will therefore serve to illustrate all the knowledge acquired up to the present time, without special reference to the many experiments previously made. The disc was placed in its cell on March 25, 1891, and mounted upon the machine; it was then carefully levelled and centred by means of the screws on the table of the machine, and rough grinding was commenced. The lead tool was used with No. 12 emery for coarse grinding. The rate of abrasion was on the average 0·03 inch a day.

From March 25 to April 22 the rough grinding of the mirror with this heavy lead tool was in progress, and on April 22 the mirror was found to nearly fit the templet, and the further use of the lead tool was not considered advisable. In all, 162 hours had been occupied in grinding, and 4 cwt. 2 qrs. 21 lbs. of emery used, the grains being Nos. 12, 20, and 36.

From April 23 to April 28 $33\frac{1}{2}$ hours were spent in grinding the mirror with the convex grooved-iron tool and giant corundum of a fineness equal to

about No. 80 emery. By this work the deep pits left by No. 36 emery were completely ground out, and a surface free from scratches produced. During this time the tool was allowed to exert its full weight, no counterbalancing being resorted to. On April 29 and 30 No. 120 emery was used with the unbalanced iron tool, and after four hours' work the pits due to the giant corundum were ground out, and a perfect 120 surface obtained.

It was considered advisable to fine up the surface as rapidly as possible, and to polish sufficiently to enable preliminary testing to be done, so that all doubts as to surface of revolution could be decided and the focus accurately measured. Two hours' grinding with No. 150 emery and the grooved iron tool with four counterbalancing weights of about 65 lbs. each, twenty minutes' with the glass tool and No. 150 emery, and twenty minutes' with "one-minute" washed flour emery gave a surface sufficiently good to polish. Four hours' polishing with the lead-resin polisher (really the figuring tool) gave sufficient polish to enable an examination for figure and a measurement of radius of curvature to be made. A very good surface of revolution resulted, no trace of ellipticity of image being detected on most careful examination. The radius of curvature was found rather shorter than required, and it was decided to re-grind, working specially on the edge, so as to flatten the curve and increase the radius of curvature.

Grinding with the glass tool for one hour and three quarters, using "one-minute washed" flour emery, and polishing for a total of nine hours and a half, in four days gave a mirror with far too much aberration, and, as this could not be removed in figuring without considerable difficulty, grinding was again resorted to.

Two hours with the 23-inch glass tool and washed flour emery gave an apparently perfect surface, and this was polished for six hours and a half with the lead-resin tool, and for eleven hours with the 30-inch slate-resin tool, the work extending over eight days. Two hours' polishing a day was found quite sufficient, one hour being given in the morning and one in the afternoon. At the end of May the aberration was nearly correct, but a close examination of the surface showed that a few of the pits due to the No. 150 emery were still left in the mirror. It was decided, therefore, to remove these by re-grinding.

On June 2 the mirror was re-ground, for the fourth time, with the glass

tool and finest washed-washed flour emery. The polishing was commenced with the 30-inch slate-resin tool, and fourteen hours and a half of this gave a nearly perfect polish, with a total aberration of about four-fifths of the theoretical, although this aberration was not correctly distributed among the zones.

The figuring tool—the 15-inch lead-resin polisher—was therefore used from June 9 until June 24, ten-hours-and-a-half's polishing and figuring being distributed between these days. The progress towards the perfect figure can be traced from the diagrams, most rigid testing being adopted on every night during this time. The surface of revolution was perfect during the whole time, and all the tests, described in the section on testing, were most satisfactory.

On June 24 the last work was done on the mirror, but the testing was continued up to July 1. On July 3 it was silvered, and on the 14th was fixed in the telescope.

The total period taken for the actual work was from March 25 to June 24 inclusive, or exactly three months.

The machine was actually in use for $273\frac{1}{2}$ hours, and, at 25 strokes a minute, this gives a total of 410,250 strokes to make a flat disc into a nearly perfect mirror.

For the rough grinding of glass ordinary sand may be used with advantage: it is cheap and cuts well, but not having a supply at hand I have always used emery. This is supplied by the manufacturers at about 24*l.* per ton in all sizes, from No. 12, which is about $\frac{1}{10}$ inch in its greatest length, to No. 150, which is a very fine powder, distinctly granular to the feel. Beyond this the finer qualities are called "flour" and "washed flour" emery. I believe it to be the practice of opticians to obtain their finer emeries from the washings of the residues obtained by the working of coarser emeries on the glass, but I have found it more cleanly and easy, to get my fine emeries by washing the ordinary "washed flour emery" as sold. To get the first "washed flour" the plan adopted is to mix the emery with water and allow a few seconds to elapse before pouring nearly the whole of the mixture into a settling vessel. In this way any stray particles of coarse emery remain in the first vessel. The emery that settles in the settling vessel is a mixture of very fine emery with that of less fineness down to washed flour simply. By washing again and allowing 1, 2, 5, 10, or 20 minutes to elapse before the mixture is poured into the settling vessel, emeries that go by the

name of the time during which the mixture is left before the water bearing them in suspension is poured off are obtained, and the first is the ordinary washed flour free from the finer kinds.

In using these finer emeries the tool, if heavy, is very apt to get too close to the glass and tear it up. The use of a small quantity of soap dissolved in the water was found a distinct advantage. A somewhat similar effect is produced if the emery has with it a certain amount of very finely ground glass, such as is produced by previously grinding, but the cutting power is much reduced.

For polishing, either rouge, or oxide of tin (putty powder, to use the commercial term), may be used. Before using either of these it is very important to mix with plenty of water so that any heavy particles will settle and thus be got rid of, otherwise a surface free from scratches can never be obtained. It is hardly necessary to say that in practice the most scrupulous care in every stage is absolutely needed to get rid of all the emery of the previous stage. This is of great importance in the finer grinding. The use of plenty of water, which itself must be free from sediment, is imperative.

In using the rouge it is of importance that the vessels in which it is kept should be placed somewhere near the mirror, so as to have about the same temperature as the mirror.

There are many practical points in the actual working that must be attended to. The chief of all is to guard against the effects of change of temperature. The mirror should be carefully protected from draughts of cold air during the night; the cover should be taken off the first thing in the morning, and the mirror kept moving. In grinding, particularly when the finer grinding is being done, the iron or glass tool should never be left for many minutes at rest on any portion of the mirror.

In figuring the result of the night's testing is considered and the stroke to be used determined. The mirror is then dusted with a fine brush or a soft towel if necessary, and painted all over with a mixture of rouge and water; one application generally sufficing for one hour's polishing. The polishing tool is then examined, and if the previous day's work has flattened the squares of resin and caused them to partly fill up the grooves, the edges are clipped or bevelled off to clear the grooves, and the tool is carefully washed. It is then hung on the balancing lever and carefully deposited on the mirror; the rods

are connected, and the cranks set so that the tool shall work from the centre to the edge of the mirror. The machine is moved by hand till the tool has gone over the whole surface, and this movement by hand is done every few minutes for half an hour. The rods and cranks are then adjusted to the determined stroke, and one hour's work done right off. The mirror is then washed with as little water as possible and covered up, sometimes to be polished again for one hour in a similar manner, though I do not like to polish more than one hour a day when figuring.

It is much more satisfactory to polish in wet weather, as the particles of dust in the air which give rise to minute scratches are almost absent in damp weather, and, as a rule, the temperature is more nearly constant.

V.

Figuring and Testing.

Thanks principally to Foucault, the method of testing a concave mirror at the centre of curvature has been so accurately worked out that it is possible to completely finish a mirror with almost absolute certainty of perfect figure without examining an image of a star produced by the mirror.

The large size of the five-foot mirror and its arrangement on the machine rendered it extremely awkward to examine a star with it, except at a low altitude, so the whole of the operations were regulated by testing with artificial light at the centre of curvature; and it was only after the mirror had been silvered and mounted in the telescope that it was possible to examine with care any celestial object.

Smith, in chapter ii., p. 309, of his book on Optics, published in 1738, gives what I believe to be the earliest account of the appearance of a concave mirror when examined at the centre of curvature, and shows how this could be used for testing mirrors and judging their figures. His idea was not followed up, and all the early workers relied either upon a particular setting of the machine to produce a definite curve, or upon the testing on some terrestrial object, getting a good figure by chance rather than by any method. With the long focal lengths of the earlier telescopes the spherical curve, if good, was as likely to give a fine image as the parabolic curve, and

the makers, up to a comparatively recent time, had no means of telling whether a mirror was good or bad by any system of measurement, optical or otherwise. As Sir John Herschel says in his book on the "Telescope," page 81 :—

"And here we may once for all remark that *that* is a good form which gives a good image; and that the geometrical distinctions between the parabola, sphere, and hyperbola become mere theoretical abstractions in the figuring and polishing of specula, there being no practical mode of ascertaining by any system of measurements on a scale what form the surface has, apart from its optical effect on the rays of light."

The method of testing at the centre of curvature, as developed by Foucault, Draper, and others, permits an examination of the nature of the surface to be made, and the approximation to a parabolic figure determined with an accuracy far beyond any mere estimation of figure. The method is, moreover, simple in practice and easily understood in theory. The reflecting power of glass at nearly perpendicular incidence is very great, even if the glass is only partially polished ; after two hours' polishing the mirror usually reflects enough light to enable its figure to be examined and the departure, if any, from a true surface of revolution determined.

If a point of light, such as is obtained by placing a pinhole in a metal screen before the flame of an ordinary oil lamp, is placed an inch or so on one side of the principal axis of the mirror, at a distance from the mirror equal to its radius of curvature, an image of the pinhole is formed on the other side of the axis and in the same plane through the axis as the pinhole. This image, when examined, will tell almost everything that is required to be known of the surface of the mirror.

If the mirror is perfectly spherical the image is an exact reproduction of the pinhole, with the addition of one or more diffraction rings around it. The cone of rays from the mirror is equally filled with light in every section, and, however small the pinhole is made, the whole surface of the mirror is seen equally illuminated if the eye is placed at the focus so as to receive all the light. If, instead of receiving the full image of the pinhole or reducing the pinhole in size, the image at the focus is partly intercepted by a screen, the light then reaching the eye comes equally from all parts of the mirror, and there is no irregularity in illumination of the surface. Under no circumstances, so long

as the mirror is of spherical surface, can any interruption of the rays at the exact focus cause any unequal illumination of the mirror, for diminishing the size of the image is exactly equivalent to reducing the size of the pinhole. The slightest deviation from the true sphere can be detected at once by interrupting some of the light at the focus of the mirror, for, owing to the difference in focus of the rays reflected from different portions of the mirror, and consequent unequal interruption, by any object placed in the focus of one cone, the illumination becomes unequal. A perfectly spherical figure is exceedingly difficult to obtain, if it ever has been obtained, although the test for it is an absolutely rigorous one.

With a mirror still a perfect surface of revolution, though not a spherical one, the amount of deviation from the sphere can be estimated very readily, and the direction of deviation, whether towards the parabola or hyperbola, is at once apparent.

I may say at once that in my opinion, if the mirror is not a perfect surface of revolution it is absolutely hopeless and should be at once re-ground. Departure from the sphere, either towards the parabola or hyperbola can be dealt with in the figuring, but any irregularity of figure round the axis is at once fatal and cannot be properly corrected by figuring.

In the case of the parabolic mirror, when tested at the centre of curvature, we have the focus for the rays from the outside zones of the mirror longer than for the rays from the central portions. With the lamp in one fixed position at a distance from the mirror equal to its radius of curvature, the distance of the focus of one particular zone behind the image produced by the central portion of the mirror is determined with sufficient accuracy by the formula $a=\frac{\frac{1}{2}D^2}{R}$, where a=the aberration or difference in position of the image, D=the diameter of the zone, and R=the radius of curvature of the mirror, the source of light remaining fixed.

I know of no practical use for the hyperbolic mirror, so that it is unnecessary to enter into any discussion of its peculiarities, except to say that with it the focus of the rays from the outside zones falls between the mirror and the focus of the rays from the central portions of the mirror.

The course of the rays can be at once appreciated in the case of the spherical, parabolic, or hyperbolic, mirror by introducing a screen into the

image at the centre of curvature of the mirror. In the case of the spherical mirror, as we have seen, the mirror is always equally illuminated, since all light reaches the same focal plane, no matter which portion of the mirror it is reflected from (fig. 22). In the case of the parabolic mirror the focal plane of the

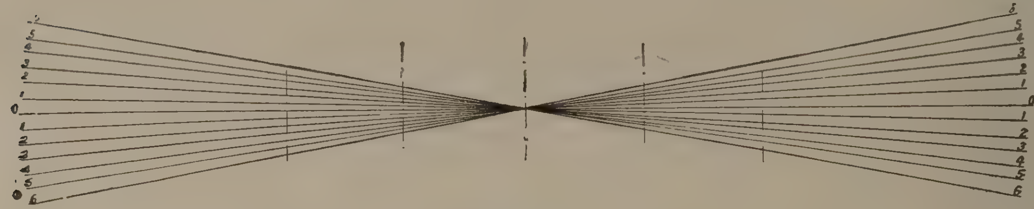


Fig. 22.

light from the central portion is nearer the mirror than the focal plane of the light from the external portions. Sections of the cone of rays taken at different planes at or near the best focus will show unequal illumination ; this will be readily seen from the diagram, fig. 23. A section inside the plane of least confusion will show a central condensation and a less bright edge ; at the

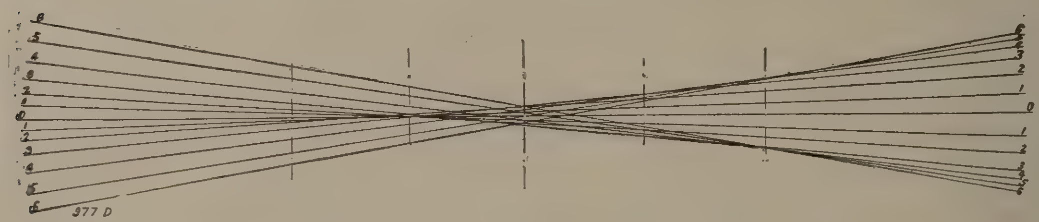


Fig. 23.

plane of least confusion the image is of its smallest size, although no definite image of the pinhole is formed. Outside this plane a nearly dark centre is formed, surrounded by a ring of light, the outside edge of this ring being brighter than the rest of the image. This will be seen by the closeness of the lines at these points. In the case of a hyperbolic mirror the curvatures are reversed. To determine the differences in focus between any zones of the mirror is a simple process. Wood or zinc screens are placed in front of the mirror, leaving successive zones uncovered. Each zone forms an image of the pinhole, and by means of an eyepiece mounted on a slide moving in a groove graduated to inches and hundredths of an inch

we can accurately focus this image ; the differences in the positions of the foci of the zones being at once read on the graduated slide. Thus, with all but the central 3 inches covered up the eyepiece slide is in the position 0 on the scale when the image of the pinhole is perfectly sharp ; then, on covering up the central 3 inches and opening a ring 1 inch wide and with a mean radius of 12 inches, the eyepiece slide has to be moved away from the mirror to give a sharp image to the pinhole. The slide indicates that the eyepiece is moved out, say, $\frac{1}{10}$ inch ; then we know the actual numerical value of a is $\frac{1}{10}$ inch, and we can compare this with the theoretical value calculated from the formula given. In an exactly similar manner the value of a for all zones is actually measured.

The degree of accuracy with which this focussing can be done is really surprising, independent readings agreeing within $\frac{1}{100}$ inch. The comparison of these measurements with the theoretical values, and a further test of the whole surface for general regularity and freedom from rings, are quite sufficient to enable an accurate estimate to be made of the existing figure, and to indicate where work is necessary to change the figure.

A little consideration will show that, in testing the regularity of surface of a spherical mirror by diminishing the size of the image formed at the radius of curvature, or, what is the same thing, reducing the size of the pinhole, we are dealing with light in one plane only, whereas with the parabola we have an image to deal with which is built up of successive images formed one behind the other, over a distance equal in length to the total aberration of all the zones. A screen moved across the cone of rays within the planes of the focus for the long and short rays will act differently according to its position, as an examination of fig. 23 will show. Moved across in the plane of focus of the shorter rays, the effect will be simply to cut off the light regularly from the face of the mirror ; but when the screen is shifted to the plane of the focus of the rays from the edge of the mirror, a moment's inspection of the diagram will show that the light will be cut off in quite a different way. In the latter case all the rays from the mirror except those from the edge have crossed the principal axis before they reach the screen. The rays from near the centre have crossed first, and the planes of foci of the other rays lie further and further from the mirror, and therefore closer and closer to the screen, the nearer the zones from which they are reflected are

to the edge of the mirror. The inclination at crossing is greater with rays from near the edge than it is with rays from near the centre of the mirror, and this, in combination with the differences in position of the planes of foci of the rays, will cause the screen, when moved in the plane of focus of rays from the edge of the mirror, to cut out some of the light from the inner portions of the mirror before affecting the light from the edge. The rays which have crossed and are divergent are cut out before those rays from the edge which are exactly crossing the principal axis in the plane of the screen. In other words, it will be seen that there is a point on the mirror, the rays from which, having come to a focus and crossed the axis, are first touched by the screen, moving as already mentioned in the plane of the focus of the rays from edge of mirror. The eye viewing the illuminated surface of the mirror will therefore see this point darkened first as the screen is moved across. This darkening spreads over the surface of one-half the mirror, and continues in the reverse way over the other half, till the last remnant of light disappears at the point opposite to that at which the darkening began.

In place of a screen the iris of the eye can be used easily, the head being moved slowly so that the pupil of the eye cuts the zone exactly as the screen does, all irregularities of the surface being immediately shown up as irregularities of illumination, and any ridges in the mirror becoming very prominent.

An exceedingly good preliminary test of the figure is to use a piece of fine perforated zinc, with holes about $\frac{1}{30}$ inch diameter and $\frac{1}{15}$ inch apart, or a piece of fine gauze in place of the pinhole. The image of this examined directly with the eye, or with a low-power eyepiece, is very useful for determining the regularity of the figure and for judging the amount of aberration.

With a spherical mirror all the images of the holes are round, no matter where the eye is placed outside the centre of curvature. With a parabolic mirror, on passing the eye in, the central holes remain circular, while the holes seen apparently on the edge of the mirror are elongated into ellipses, with their major axes all pointing towards the centre of the mirror. As the eye travels farther in these are elongated more and more until the outside ellipses apparently coalesce. This effect can be traced in farther towards the focus by artificially reducing the pupil of the eye by viewing the image of the zinc grating through a small pinhole, and with this addition any deviation from a true surface of revolution, and any irregularities of figure, are obvious,

owing to the irregular distortion of the holes thus viewed. Carrying the eye still further in, the mirror can be seen apparently convex, with the image of the grating sharply defined on it; any irregularity being just as readily detected with this view as it is with the ordinary view after the rays have crossed. In the actual testing of the five-foot mirror, the lamp used is a small microscope lamp burning paraffin oil through a small flat wick. The chimney is of metal with a slide in front that takes glass slips 3 inches by 1 inch in size. In place of the glass slips, I have strips of sheet tin with various holes in them. Another plan which I found exceedingly convenient was to have a series of holes arranged in a revolving screen fixed in front of the glass plate, so that the different images given by the holes could be readily compared, and risk of moving the lamps during testing avoided as much as possible. One of the holes, about $\frac{1}{100}$ inch in diameter, is used for testing the zones, and will permit zones $\frac{3}{4}$ inch to 1 inch in width to be accurately examined. The zones near the edge of the mirror can, of course, be of less width than the central ones because of the greater circumference. The central 6 inches of the mirror are read in one zone, the light from these portions nearer to the centre coming to a focus at such an acute angle that differences of aberration are not discernible in the readings.

In testing mirrors of short focal length it is better to use a right angle prism in front of the lamp, which may then be placed sideways; this enables the angle between the incident and reflected ray to be kept very small, a matter of some importance with large aperture mirrors.

The whole surface of the mirror in testing is divided by screens into fourteen zones. The eyepiece chiefly used for determining the difference of focal plane is one by Dollond, and magnifies about ten times, and the accuracy possible in reading is shown by the sample of three readings in one night, selected at random from the book. The eyepiece is mounted in an adapter fitted to a slide moved by a simple rack and pinion, the edges of the slide being divided so as to enable differences of $\frac{1}{10}$ inch to be read directly on the edge, and of $\frac{1}{100}$ inch by a vernier.

The usual plan adopted in testing is to fix the lamp and the eyepiece as close together as possible, to centre the eyepiece by racking it in and out, the image remaining central in the field during this operation. Then the screens with the zones cut in them are put on, and the aberrations measured

in the order in which the zones come, on the screens in Table I. At the end of the operation the table of observed aberrations is made out and compared with the theoretical aberrations, but for working purposes I have generally plotted out the results of the testings graphically as on fig. 24.

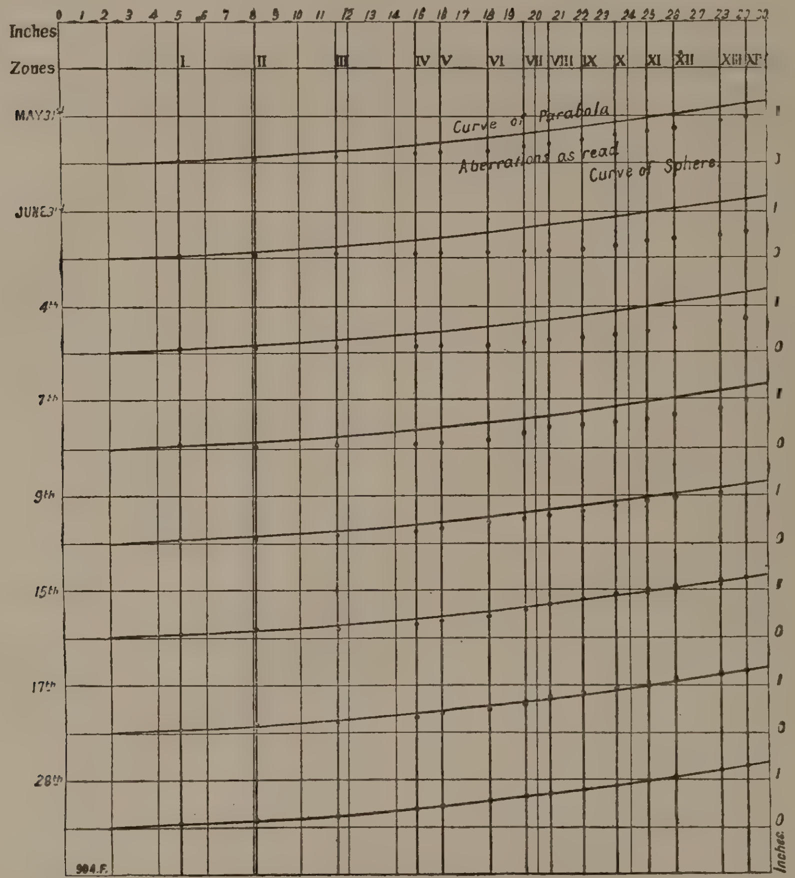


Fig. 24.—Diagram of one-half of mirror.

A straight horizontal line represents the sphere, there being no aberration whatever on measuring the zones of a spherical mirror. The length of the line was taken as half the radius of the mirror, and the zones were indicated on this scale. The vertical scale is double that of the horizontal scale. The theoretical aberrations for the zones of a perfect parabola were then indicated by points above the line, at distances from it corresponding to the full

theoretical aberration. A curve joining these points was taken as representing the true curve of parabolic aberrations, and the actually observed aberration for each of the zones was marked by round dots above the line of the sphere, and these joined together gave another curve which indicated at a glance all the shortcomings of the surface of the mirror. From time to time the strokes were altered to bring the curves nearer together, and the gradual approach of the curves can be readily followed. In order to make the diagram more clear the curve joining the round dots has not been drawn.

Examined by the grating with the eye, the mirror at once shows the aberration, but with a pinhole of about $\frac{1}{100}$ inch and a power of 10 in the eyepiece a still further test is possible. The image of the pinhole can be seen beautifully sharp at the plane of focus of the central portions of the mirror; and this pinhole is surrounded by a nebulous ring, less bright towards the edge, the size of the ring depending upon the aperture of the mirror and its radius of curvature. As the eyepiece is brought farther away from the mirror the nebulous ring contracts, and the central image becomes diffused until the point of least confusion is reached. Anywhere between best central image and least confusion any rings in the surface of the mirror are very prominent. After passing the best central image the light begins to increase round the edge of the section, and the rings, if any, again assert themselves.

A mirror under-corrected or over-corrected may give all the indications of perfect figure as far as the appearance of the grating, the production of caustics, and absence of rings are concerned, and it is only with the zone-readings that any thoroughly reliable estimate of a mirror's excellence can be obtained without examination of the image of a star.

Table I. gives the particulars of the five screens used, giving the five screens, lettered A to E, in the first column; the distinguishing number of the zones in the second column; the inner and outer radius of each zone in the third and fourth columns; the mean adopted radius of each zone as taken in the fifth; and in the sixth the calculated longitudinal aberration of each zone after deducting that of the first zone.

In reading the zones, each screen with all its zones is read, all the zones except one on the mirror being covered by temporary rings of zinc, so that the readings do not follow in any regular order.

Table II. gives the distinguishing number of each zone in the first column, the three separate readings of each in the next column, the accepted mean of these readings in the third column, and the computed aberration in the fourth.

TABLE I.

Screens.	No.	Inner Radius.	Outer Radius.	Mean Radius.	Aberrations – the Aberrations of Zone 1.
		in.	in.	in.	in.
A	1	4·00	6·00	5·099	·000 (·0406)
B	2	6·25	9·75	8·189	·0627
C	3	10·00	13·00	11·597	·167
B	4	13·50	15·50	14·457	·281
D	5	15·13	16·88	16·024	·355
E	6	17·19	18·88	18·051	·461
A	7	18·75	20·13	19·578	·550
C	8	19·88	21·25	20·576	·612
D	9	21·25	22·63	21·948	·702
E	10	22·75	24·00	23·383	·802
A	11	24·00	25·38	24·677	·900
D	12	25·38	26·50	25·944	·997
E	13	26·75	28·38	27·798	1·128
C	14	28·44	29·25	28·842	1·240

TABLE II.

No. of Zone.	Observed Readings.			Mean Aberration – ·75.	Computed Aberration.
1	·75	·75	·75	·00	·00
2	·82	·82	·82	·07	·06
3	·92	·92	·93	·17	·17
4	1·00	1·00	1·00	·25	·28
5	1·10	1·11	1·11	·36	·36
6	1·22	1·22	1·22	·47	·46
7	1·31	1·31	1·31	·56	·55
8	1·40	1·40	1·40	·65	·61
9	1·48	1·47	1·47	·72	·70
10	1·55	1·55	1·55	·80	·80
11	1·66	1·66	1·66	·91	·90
12	1·78	1·77	1·77	1·02	1·00
13	1·89	1·88	1·88	1·13	1·13
14	2·00	2·00	2·00	1·25	1·24

VI.

Silvering.

The process of depositing an opaque film of silver on the surface of a glass mirror, the film being of sufficient tenacity to take a high polish, is one that is easily performed with a small mirror that can be suspended face downwards without any serious risk. With a five-foot mirror, however, some modification of this process is necessary, but all difficulties of silvering have been successfully overcome, and the operation presents no serious difficulties with the five-foot, and would present none even with a mirror of larger aperture.

The process used for the five-foot mirror was a modification of the well-known sugar process, due to Brashear, that has been so frequently published in scientific journals. Many other processes have from time to time been published, differing chiefly in the reducing agent employed. The process in which Rochelle salt is used, as described by Dr. Draper, is an excellent one and gives good results in depositing silver; a process published by Martin is also good, but uncertain.

I have obtained the best results from a modification of the Brashear process, in which loaf-sugar is the reducing agent, when the mirror is placed face downwards, using another modification for silvering face upwards.

The most important thing in this process is the sugar solution forming the reducing agent; this is greatly improved by keeping, a solution which has been made some months acting very much more rapidly than a solution newly made. To a 10 per cent. solution of loaf-sugar in distilled water I add 10 per cent. of alcohol (pure) and $\frac{1}{2}$ per cent. of nitric acid; several Winchester quarts of this solution are always kept ready. Solutions of 10 per cent. of silver nitrate and caustic potash are separately made. These solutions, with sufficient ammonia, are all that is required, but it is advisable to have a very dilute solution of silver nitrate, say $\frac{1}{2}$ per cent., and also one of similar strength of ammonia, in order to obtain the pale brown colour of the ammoniated solutions before the addition of the reducing agent. A word of caution may not be out of place with regard to a fulminate of silver, which has a tendency to form in the ammoniated solution if it is allowed to stand. This silver is highly explosive and should not be allowed to form; it can be recognised

by its dark bluish colour and metallic lustre. A few particles at the bottom of a beaker were on one occasion exploded by the impact of water from the tap, and left nothing but the piece of glass held between my finger and thumb. In using this process the ammonia is added to the solution of nitrate of silver until the precipitate first formed is re-dissolved. A solution of caustic potash, containing a weight of that material equal to one-half the weight of nitrate of silver used, is then added to the ammoniated solution of silver nitrate. A brown precipitate is again formed and is re-dissolved by the addition of more ammonia. After the solution is thus cleared a dilute solution of nitrate of silver is added, until a light brown colour is produced, somewhat darker than pale sherry. A quantity of the sugar solution, containing a weight of sugar equal to one-half that of the nitrate of silver used, is then added to the solution of silver and potash, and the previously cleaned disc is suspended *face downwards* in the mixed solutions, care being taken to exclude air-bubbles. In from three to five minutes a film of silver begins to form on the mirror, the solution having in the meantime turned pink, dark brown, and finally black; the film thickens rapidly, and in from twenty-five to thirty minutes the liquid has turned light yellow and a thin film of metallic silver is formed on its surface; the operation is then finished, and the mirror can be lifted, washed well in distilled water, and the film allowed to dry while the mirror is standing on its edge. It is advantageous to soak the mirror for some time in distilled water, say for two hours, or even in absolute alcohol for a similar time, to eliminate all trace of caustic potash and to ensure uniform and rapid drying. A temperature of 65° F. is found best for this operation, using the quantities given. With a lower temperature it is necessary to use more of the sugar to obtain a film of the required opacity, but with the temperature above 65° F. the weight of sugar used can be less than one-half that of the silver and may be reduced to one-third with a temperature of 75°.

When the film is well washed and dried it is usually of a blue colour, covered with a light "bloom" of a yellow tint; this "bloom" can be rubbed off and the film consolidated with a pad of cotton wool in chamois leather, and the film then polished by a similar pad covered with a little perfectly dry, well-washed rouge. The film thus obtained is equal in reflecting power to the best polished silver surface, and will retain

its brilliancy for several months if carefully covered whenever it is not in use.

The process of silvering face downwards was used for silvering the 16-inch flat mirror of the 5-foot telescope, and the films obtained by it have given every satisfaction in use. They are opaque, brilliant, and permanent, far superior in the two latter respects to the surfaces obtainable on speculum metal.

In silvering glass surfaces by this process the surface to be silvered must always be arranged face downwards in the solution. A thick mud is formed in the liquid, and this settling on the surface of the mirror, if silvering face upwards is attempted, almost invariably spoils the film by rendering it porous. For the 3-foot mirror the method of silvering face downwards was also adopted. To overcome the risk of suspending the mirror solely by bands round the edge, I devised a method of holding the mirror by pneumatic pressure. In this method a flat iron dish was laid on the back of the mirror, the joint between the edge of the dish and the mirror being a sheet of indiarubber; the air was then partly exhausted from the dish, and the pressure of the external air held the mirror tightly to the dish. The mirror was in this manner suspended face downwards for the operation of silvering. With the 3-foot mirror this answered perfectly, but there were difficulties about a similar arrangement for the 5-foot that rendered it necessary to adopt another process. The great size of the 5-foot and its enormous weight (more than half a ton) rendered all band support round the edge dangerous, and the hole in the centre made the fitting of the pneumatic apparatus difficult, and it was absolutely necessary to silver it face upwards. The method adopted was as follows:—A strong band of paper dipped in melted paraffin was stretched as tightly as possible round the mirror and firmly clipped to it by a copper band with tightening screws; the paraffined band stood up 2 inches above the edge of the mirror and was luted to it by more paraffin and a hot iron, so that the fitting was water-tight. A plug of metal covered with paraffin was fixed in the 10-inch central hole, a small hole $\frac{1}{2}$ inch in diameter and connected with a tube being left in the centre of this plug. The tube passed through the cell and acted as a waste-pipe for drawing liquids off the mirror. The joints of the paraffined plate or plug and the mirror were made water-tight

with paraffin, and the mirror thus converted into a dish with a small hole in the centre. The hole could be plugged with wood covered with paraffin and the mirror could then be entirely covered with water to a depth of 2 inches at the edge if necessary.

The plug in the orifice of the tube was temporarily removed and the mirror carefully cleaned. For this purpose it was scrubbed with cotton wool dipped in a strong solution of caustic potash, then washed down with water, scrubbed again with cotton wool and absolute alcohol, and after another washing with water, thoroughly scrubbed with cotton wool and strong nitric acid. After washing this off the mirror was rinsed with distilled water, the plug forced into the small hole, and the mirror covered with distilled water until the silvering solutions were ready.

The first attempts to silver the five-foot were made with the process already mentioned, great care being taken to filter all the solutions before use ; but the film was always full of pinholes through particles lying on the surface, although the mirror was kept in motion during the whole time. Finally it was silvered successfully by the process that is already given, but without any potash.

Experiments were made on small mirrors with a view of getting rid of this mud, which was shown to be due to the potash, and it was found that without the potash the process gave as good a film as with it, but took very much longer to deposit the silver of a sufficient thickness.

The mixed solutions were poured on to the mirror after the distilled water had been drained off, and allowed to remain on for two hours ; a film began to form in about twenty minutes, and at the end of two hours it was found, from trials with a portion of the same solution on small mirrors, to be sufficiently thick to be opaque. At the end of the two hours the solution was found to be nearly as clear as at the beginning of the operation. A thin yellowish "bloom" covered the film, but this polished off as before, and the metallic silver took a perfectly "black" polish.

The disadvantages of this process are the large quantity of nitrate of silver required (500 grammes for each operation), the great slowness of deposition, and the risk of stains or spots on the film from any precipitate, or from any accidentally introduced solid matter that may be in the liquids used.

The first two films obtained on the five-foot were produced in this way, and were very satisfactory, not only on account of brilliancy of polish, but also on account of their permanency. One was in use for twelve months, and the other for nine, and yet no serious deterioration could be seen with them; the film was cleaned off in each case to allow of the refiguring before mentioned, and not from any faults of the films themselves. As an experiment the last film was deposited by the Rochelle salt process, and this seems to stand very well; in this process no mud is formed, and the silver film is without pinholes.

In the ordinary way of silvering face downwards the proportion of silver nitrate is 1 ounce to 250 square inches; in the process without potash, a proportion of about $1\frac{1}{2}$ ounce to this area is used. The amount of silver is greatly out of proportion to the total amount deposited on the mirror, but, as very nearly all the unused silver can be easily deposited from the waste solution by common salt, and the silver readily reduced from the chloride thus obtained, there is not much loss. Dr. DRAPER gave the thickness of the silver film as $\frac{1}{200000}$ inch. I took the opportunity when removing a very fine film from the five-foot mirror to dissolve the silver in nitric acid and carefully collect it; the assay of the deposit made by Messrs. Johnson & Matthey gave 26·5 grains as the total weight of silver on the whole surface of about 2,800 square inches, equal to a thickness of $\frac{1}{280000}$ inch almost exactly; in actual weight of silver somewhere between that of a threepenny and a fourpenny piece.

VII.

MOUNTING OF THE MIRRORS.

The mounting of a large piece of glass in a cell in such a way as to reduce the evils of flexure to a minimum becomes of great importance when the glass is thinner than about one-sixth of its diameter. The plan here adopted is similar to that which I employed for the mirror of the 3-foot telescope (see figs. 25, 26 and 27). Considering the mirror to be divided into six sectors, each sector is supported by a dished plate with a broad-edge support, with the centre of the dished plate placed under the centre of gravity of the sector. Each two adjoining plates are supported in a steel lever, the centre of each lever resting on the cell; thus there is always

the same actual weight on each plate and twice that weight on each lever. Each dish is made flat, and so thin that it will easily spring to fit the glass, but sufficiently strong to bear the whole weight of the sector and any grinding tool, so that there is no danger of getting a diametrical support from two opposite sides. Edge support of the mirror is obtained in a manner similar to that used for the three-foot, but the three bands do not each go quite two-thirds of the way round. An inspection of the drawings will show the arrange-

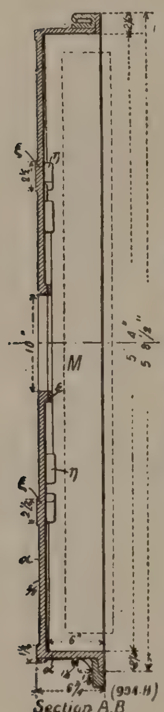


Fig. 25.

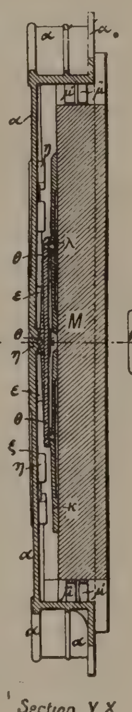


Fig. 26.

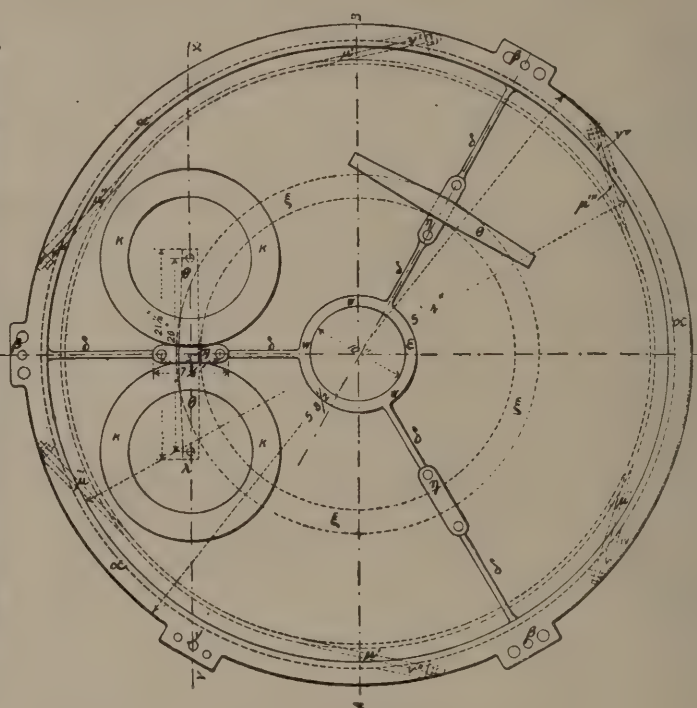


Fig. 27.

ment of the bands. On the flange of the cell three stout lugs are cast, each with three holes, two for screw attachment to the end of the telescope tube, and the middle one for a pushing screw for final adjustment of the mirror. Another lug is cast on the edge of the cell for the attachment of a wrought-iron eye or part of a hinge, the other part of the hinge being firmly attached to the end of the tube, fig. 31. This is a simple but very important addition, and renders the attachment of the cell to the tube very easy. The mirror in its cell being brought from the grinding-room to the end of the telescope tube,

the hinge is brought together and a steel pin completes the connection. This allows the hoisting of the cell to be done quickly, the hinge attachment securing prompt fitting by accurately presenting the screws when the cell is brought home, and thus preventing any damage to the edge of the mirror, which stands about $1\frac{1}{4}$ inch above the edge of the cell, and has to project into the end of the tube, so that the plate-glass cover may fit close to it.

Figs. 25, 26, and 27 illustrate the cell and the method of support used for the 5-foot mirror.

α in these diagrams is the cell itself, 5 feet 4 inches in internal diameter and $\frac{5}{8}$ thick at the sides. It is 6 inches in depth internally. The cell has a flange $2\frac{1}{4}$ inches wide in plan round the upper edge.

$\beta\ \beta\ \beta$ are the lugs on the flange of the cell α. In each of these three holes were drilled, the two outer holes being clearing holes for bolts that fasten the cell on to the end of the telescope, the centre hole in each lug being tapped for a set-screw which regulates the distance of the flange from the end of the telescope and enables the mirror to be accurately centred in the tube.

γ is an additional lug with three tapped holes into which bolts can be screwed to attach the cell to a hinge shown in fig. 31, for hoisting up into position at the end of the telescope tube.

δ are ribs or webs in the bottom of the cell, strengthening it.

ϵ is a ring round the central hole of the cell, and is the inner limit of the ribs or webs δ.

ξ is a ring round the outside of the cell, for further strengthening it in the centre of the webs δ.

$\eta\ \eta\ \eta$ are lever supports cast as part of the webs δ. These are shown in plan in fig. 25, in section and elevation in fig. 26, and in elevation in fig. 27.

$\theta\ \theta$ are the levers resting on rockers that fit into the lever supports, and are held in place to some extent by the band i.

i is a band, shown in fig. 26, that embraces the lever and attaches it to the cell, but allows the lever to rock on the rocker.

$k\ k$ are the plates, two of which are shown in the plan, and two shown in section in fig. 26. These plates are dished slightly, and the

mirror M rests on the rims of the plates, with a layer of cloth between the plates and the glass.

λ is the screw pivot of the plates, the form of hole adopted for the plates being shown in the fig. 26.

The plates k are free to rotate on their pivots λ, and the levers are free to rock on their rockers which fit into the bearings shown at η. The mirror when lowered on to the plates is therefore supported equally by six rings k.

To hold it in its place, and to keep it central in the cell, steel bands, with round tapped ends, are passed round the mirror, and through holes in the sides of the cell. Nuts are screwed on to the ends of these bands until the mirror is gripped tightly.

μ', μ'', and μ''' are these bands.

μ' commences at the hole ν' in the cell, and passes round to the hole ν''.

μ'' commences at the hole ν''', and passes round to the hole ν^{IV}.

μ''' commences at ν^{V}, and ends at ν^{VI}.

Fig. 26 shows μ' and μ'' in section and in elevation in the upper portion, and μ' and μ''' in the lower portion of the drawing.

The hole ν is shown in fig. 25.

Between these bands and the mirror a layer of cloth is fixed. When the mirror is resting on the plates k, and the bands μ', μ'', and μ''' are screwed up tight by means of the nuts, the whole of the mirror is rigidly connected with the cell, and no movements or flexure are produced, however much the mirror is moved about.

Fig. 25 is the plan of the mirror, with one lever shown with plates, one lever without plates, and one lever support without lever.

Fig. 26 is a section of the cell and mirror on the line A B of the plan.

Fig. 27 is a section of the cell and mirror on the line X Y of the plan, and shows the lever and plates in section, as well as the bands μ', μ'', and μ'''.

The cover of the 5-foot mirror is carried in the iron box at the lower end of the tube. It consists of a circular piece of polished plate glass 62 inches in diameter and $\frac{5}{8}$ inch thick, carried on a strong framework of wood firmly braced by wrought-iron bands. This cover is supported on two

arms on a horizontal shaft at the base of the telescope tube ; a strong arm attached to this shaft carries a nut at the extremity with a long screw working in it. This screw is passed through the end of the telescope tube by a ball-and-socket joint, and a handle on this end of the screw, when turned, raises the wooden frame so that the plate of glass is firmly pressed against the face of the mirror, touching the edge all round.

When the mirror is to be used the handle is turned so as to run out the screw and lower the frame until the glass cover lies in the bottom of the box. A silk flap, working on a shaft somewhat similar to the other, is then dropped over the plate of glass to prevent dewing of the glass and to avoid internal reflections.

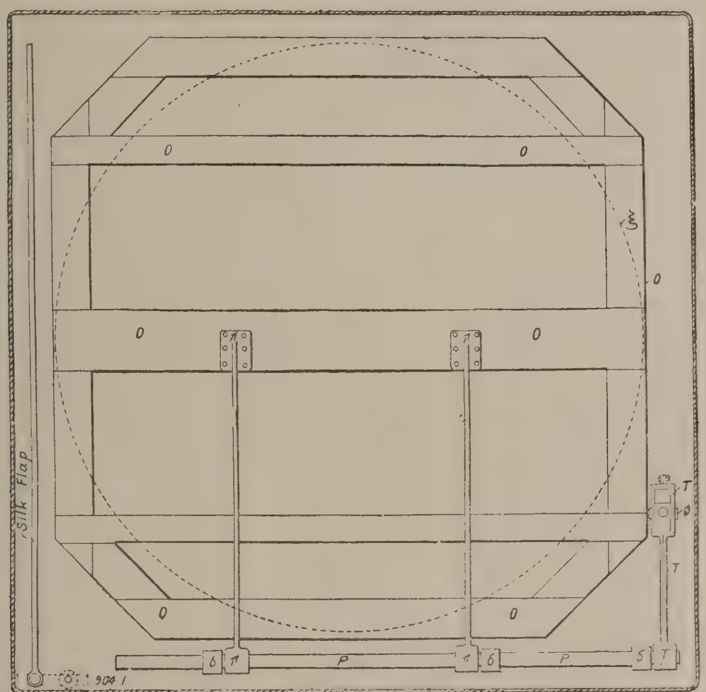


Fig. 28.

Fig. 30.

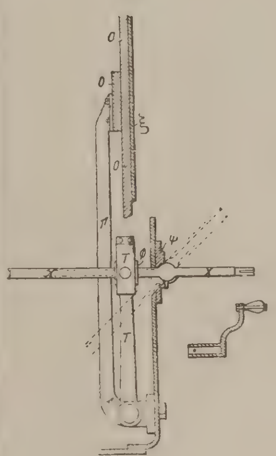


Fig. 29.

Fig. 28 is a front view of the cover of the mirror (*i.e.* looking down the telescope tube).

Fig. 29 is a part side elevation and section of the cover.

Fig. 30 is a view of the plate ψ from the handle end of the screw.

ξ is a circular sheet of plate glass ·62 inches in diameter and $\frac{3}{8}$ inch thick. This comes in contact with the mirror all round its extreme edge, and is the true cover.

o is a strong wood frame supporting the circular glass plate, the frame being strongly braced by ribs of wood.

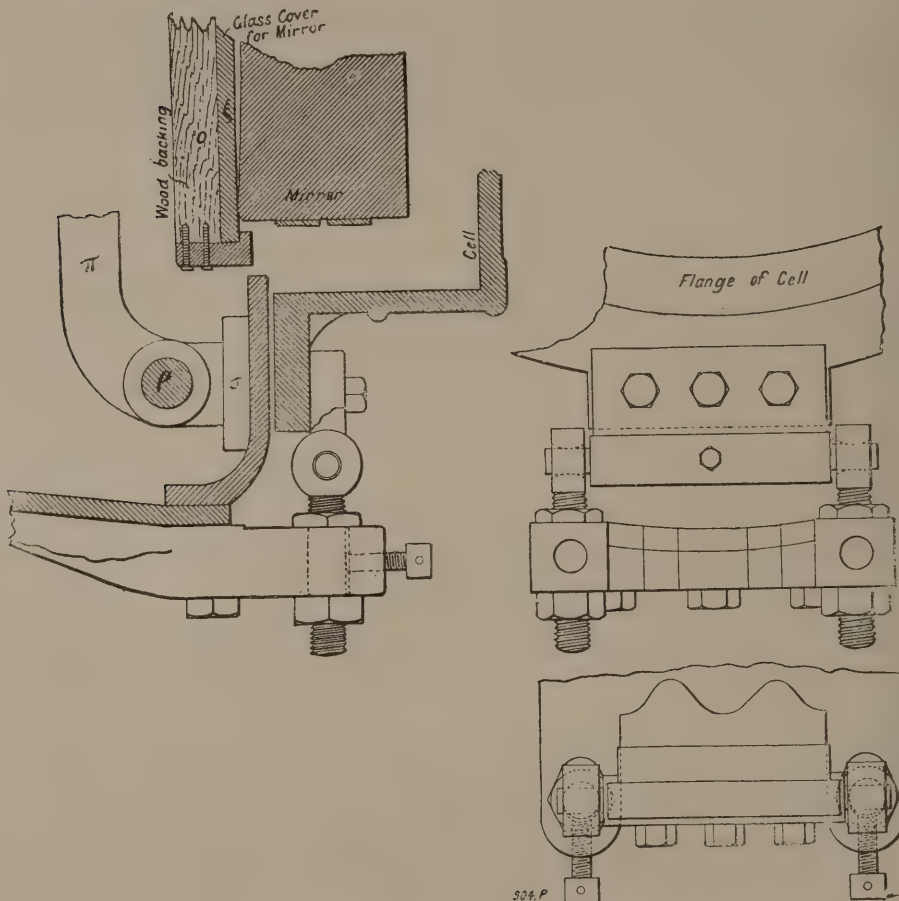


Fig. 31.

π π are two strong forged iron brackets, firmly screwed to o at their upper ends, and keyed to the shaft ρ at their lower ends.

ρ is a shaft fastened to the tube of the telescope (shown in section in fig, 31) by means of the bearings σ.

σ are the bearings of the shaft ρ.

τ is a strong iron bracket, firmly keyed at its lower portion to the end of the shaft ρ. The upper end of this is open, as shown in fig. 28.

ϕ is a gun-metal cube pivoted in the slot of the bracket τ. This cube is pierced by a hole, which is tapped.

χ is a rod 20 inches long, and has a ball in one portion of it. This shaft has a square thread which fits the thread in the hole of the gun-metal cube ϕ. The untapped end of this rod is slotted.

ψ is a gun-metal plate firmly screwed on to the end of the telescope tube, and forming a bearing for the ball of the rod χ.

ω is the handle fitting on the slotted end of the rod χ.

In fig. 29 the strong lines show the position of the cover fittings when the mirror is covered up. The handle ω when rotated pulls the tapped end of the rod χ through the gun-metal cube pivoted on the bracket τ. The handle rises by means of the ball-and-socket joint formed by ψ, for as the distance between ψ and τ is increased, since ψ is fixed to the end of the telescope tube, the bracket τ must be thrown into the position shown by the dotted lines; and this bracket being keyed to the shaft ρ carries the brackets π, also keyed to the shaft ρ, into a similarly inclined position. When the screw on χ is exhausted, the whole of τ, π, o, and ξ are lying flat on the bottom of the telescope tube. A silk flap, shown in fig. 28, and marked Σ, is then dropped over the glass plate ξ, so as to guard against reflections from the surface of the glass and to prevent dewing of the cover.

The mounting of the flat mirror, so far as the question of flexure is concerned, offered no difficulty, the ratio of thickness to diameter enabling an edge support to be used as shown in fig. 32.

The flat mount consists of an iron cylinder 24 inches long and 12 inches in diameter, with a strong gun-metal flange at each end. Into each of these flanges four $\frac{3}{4}$-inch wrought-iron rods are screwed, and these rods pass through brass tubes in the crossing-places of the ribs of the tinned-steel cylinder which forms the eye end, and are tightened up by nuts on the outside of the cylinder. The rods are braced together by four pieces of $\frac{3}{16}$-inch bicycle wire, so as to prevent any sagging when the telescope is in the vertical position. It will be seen that the outermost rods slightly diverge from the tube towards the flat

mount, while the inner set of rods lie almost in one plane ; the diagonal thin rods thus pull slightly against the outermost rods and prevent any longitudinal movement, the inner set of rods taking the principal weight.

This arrangement of two sets of four rods is better than two sets of three, which have usually been used for the support of the flat mirror, as it reduces the diffraction rays round bright stars to four instead of six.

Into the iron cylinder thus mounted a sheet-iron cone is fitted, carrying

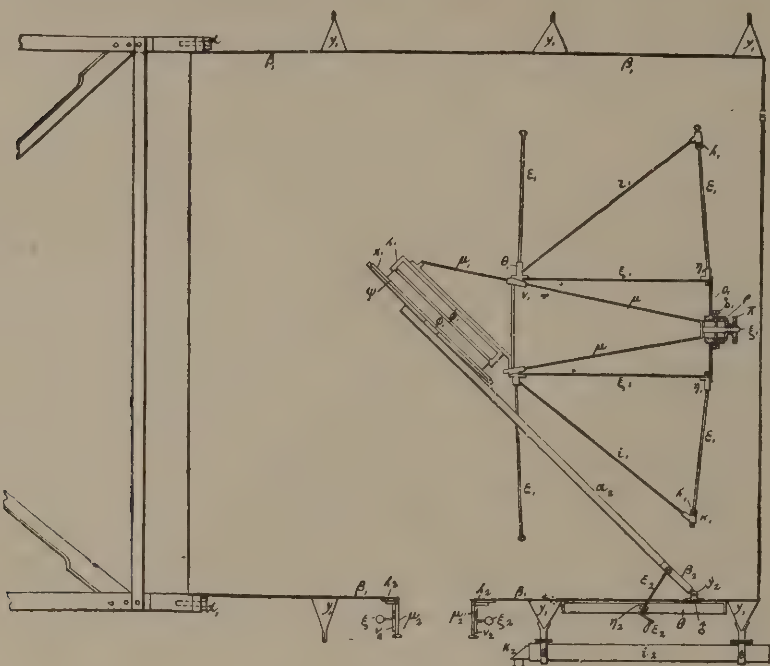


Fig. 32.

the flat at its base, the apex of the cone being fastened into a strong gun-metal plate, where the cone fits the cylinder at the other end. The fitting is part of a very large cup-and-ball joint. This allows a motion of the flat by the screws at the apex in the plane of the paper, as shown on fig. 32, and a motion of rotation in the plane of the paper, as shown on fig. 33, for adjusting the flat.

The cover for the flat is a sheet of plate-glass carried in a braced frame of wood which can be made to lie back against the side of the tinned-steel cylinder when the flat is in use, but can be thrown across the tube and placed in contact with the edge of the flat mount by means of a screw working in a

ball-and-socket joint, in a manner very similar to that which has already been fully described, in the case of the large mirror.

Fig. 32 is a horizontal section of the tinned-steel eye end of the telescope, and shows the flat and flat mount in position, as well as the cover of the flat.

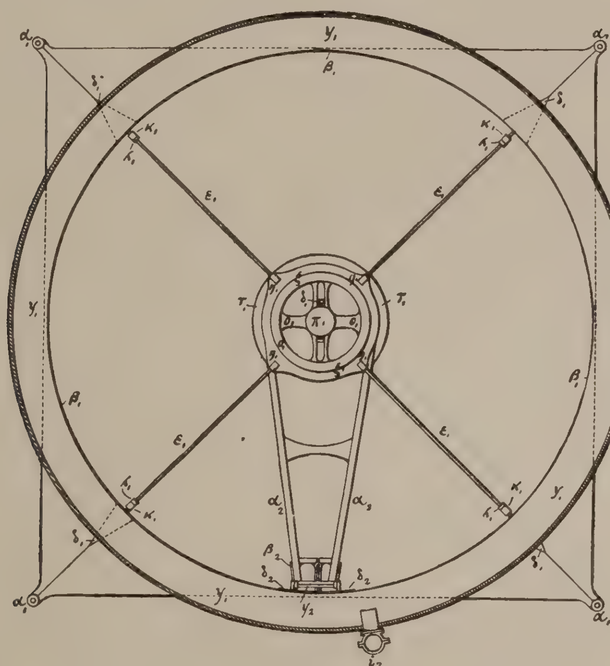


Fig. 33.

Fig. 33 is a front view of the eye end of the telescope.
Fig. 34 is a side elevation of the cover of the flat.

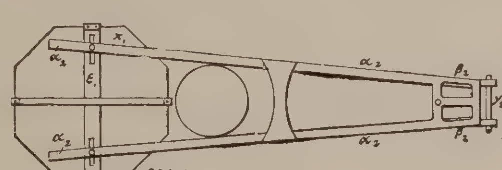


Fig. 34.

α_1 is the square iron frame with eyes at the corners for attaching the tinned-steel cylindrical end to the skeleton framework of the tube.
β_1 is the tinned-steel tube.

$\gamma_1\ \gamma_1\ \gamma_1$ are the three circular flanges of tinned steel strengthening the tube β_1.

$\delta_1\ \delta_1\ \delta_1\ \delta_1$ are the four longitudinal flanges also strengthening the tube β_1.

$\iota_1\ \iota_1\ \iota_1\ \iota_1$ are the eight rods in sets of four which are passed through brass tubes at the intersections of the flanges δ_1 and γ_1, and serve to support the flat mount.

ζ is the cylindrical tube forming the flat mount.

η_1 is the outside flange of the flat mount ζ.

θ_1 is the inner flange of the flat mount. This flange has a curved face towards the centre of the cylinder.

The rods ϵ_1 are screwed into the flanges η and θ of the cylindrical tube ζ.

$\iota_1\ \iota_1$ are additional rods to brace the front and back rods ϵ_1 together.

$\kappa_1\ \kappa_1$ are perforated gun-metal fittings sliding on the screwed ends of the front rods ϵ_1, and are held in place by the small nuts λ_1.

The additional rods $\iota_1\ \iota_1$ are screwed into the fittings κ_1 and into the flange θ_1 of the cylindrical tube ζ_1. The nuts λ_1 are then screwed down until they press the fittings κ_1 towards the tube β_1, thus tightening the rods ι_1 and firmly bracing the front and back rods ϵ_1 together. The tube ζ_1 is accurately and rigidly fixed in the centre of the tube β_1 by these braced rods.

μ_1 is a cone which carries the cell of the flat at one end.

ν_1 is a ring which serves as a flange on the cone and fits into the flange θ_1 of the cylindrical tube. The face of ν_1 is curved so as to correspond to the curve of the inner surface of θ.

ξ_1 is a tapped rod in which the cone μ_1 terminates. This is square near the cone and round only at the tapped portion.

o_1 is a gun-metal plate fitting into the flange η of the cylindrical tube ζ of the flat mount. This plate has a slot through which the rod ξ passes, considerable play being allowed.

π_1 is a round nut screwing on to the end of the rod ξ_1 in which the cone terminates.

ρ_1 is a curved-faced washer interposed between the nut π_1 and the face of the plate o_1.

σ_1 are set-screws through the flange of the plate o_1. These screws

enable the rod ξ_1 to be fixed in any portion of the slot of the plate o_1, and the curved faces of the washer allow the nut π_1 to be tightened up with this rod in any position in the slot.

τ_1 is the cell of the flat. This forms a part of the cone μ_1, but part of the ring is detachable by loosening the screws.

ϕ_1 is the flat itself fixed into the cell τ_1 by a ring; a groove in the flat mirror being filled accurately by the ridge made in the ring of τ Half of the ring can be detached so as to allow the flat to put properly into the cell, the detached portion being replaced and fixed in its proper position by suitable screws in the lugs of the ring of τ.

χ_1 is the sheet of plate glass used as a cover for the flat mirror.

ψ_1 is the ring of gun-metal fixed round the extreme edge of the flat mirror, and projecting slightly over the front of the flat. The cover glass χ_1 bears against this instead of touching the face of the flat.

ω is the wood framework supporting the glass cover. This is shown in fig. 34 in detail, the slotted bar for regulating the height of the cover being shown in that view.

α_2 α_2 are two wooden arms braced together, and carrying the glass cover at their most separated ends.

β_2 β_2 is an iron frame, to which the two rods α_2 are attached at their least separated ends. This iron frame forms the bearing for a hinge rod, γ_2.

is the corresponding portion of the hinge that is attached to the tube β_1.

ϵ_2 is a screw that fits, as a ball, at its one end into a socket in β_2, and which terminates at its free end in a handle.

ζ_2 is the handle.

η_2 is a gun-metal cube, through which the screw ϵ_2 passes.

θ_2 is one of two pieces of 1-inch angle iron, firmly attached to the lugs γ_1 of the tinned-steel tube β_1.

The cube η_2 has a pivot bearing on each of these angle irons, which are 1 inch apart; and in consequence of this arrangement the rotation of the handle ζ_2 shortens the screw ϵ_2, and pulls the rods α_2 back until

they, with the cover, lie along the tube β_1, in the position indicated by the dotted lines.

ι_2 is a 2-inch finder fixed to the flanges γ_1.

κ_2 is the diagonal eyepiece of the finder.

λ_2 is the tube for the eyepieces. This is part of the tube β_1.

μ_2 is a brass tube fixed on to λ_2 by means of six holding screws and three set-screws.

ν_2 is a tube equal in internal diameter to the external diameter of μ_2 and connected with it by means of a focussing screw, so that the distance between the face of the flange of ν_2 and the centre of the flat can be varied by rotating the focussing wheel ξ_2.

Full views of the details of λ_2 and its fittings are given in fig. 47.

VIII.

THE TELESCOPE MOUNTING.

It was essential that the 5-foot, to be useful for astronomical photography, for which it was intended, should be mounted equatorially and provided with a driving clock that would cause it to follow a star in its apparent movement for several hours without sensible error, and that the cost of the mounting should be kept as low as possible.

With the 18-inch and 3-foot telescopes already mentioned, I had lessened the friction of the polar axis by floating part of the weight in mercury in the manner shown in Vol. XLVI. of the *Memoirs of the Royal Astronomical Society*. The plan of floating part of the weight, and so getting much easier motion, was expensive when mercury was used. I had, therefore, in view of mounting the 5-foot, worked out details for the construction of a hollow iron cylinder to be used as the polar axis, and arranged to have this floated in water, the cylinder to be of sufficient diameter to carry the tube of the telescope between two horns attached to the top of it and within its diameter. The problem was to float this cylinder in water in such a manner that the bearings at the top and bottom would lie exactly in the meridian, and keep the axis of the cylinder at an inclination equal to the latitude of the place. It was first intended to use an iron tank to float the cylinder in, but this was abandoned in favour of a brick tank, protected by a lining of cement.

The details of the brick tank can be seen in the drawings of the section of the telescope (fig. 43) and in the block plan (fig. 1). The sides are 15 inches thick, the depth of the tank is 15 feet, and its width 8 feet 6 inches.

The cylinder, when floated in this tank, was ballasted with blocks of iron until its lower end was sunk in the water and borne on a ball-and-socket joint at the bottom of the tank. A strong bracket of cast iron was attached to the stone at the north end of the tank, and carried a bearing into which the pivot at the upper end of the cylinder was fitted ; this bracket was capable of movement in two directions—in azimuth, so as to get the axis of the cylinder exactly in the meridian, and in height so as to enable adjustment in inclination of the axis to be made.

The cylinder is made of boiler-plate, strongly braced inside with 2-inch angle iron. It is 7 feet 8 inches in diameter, and has a load of 9 tons of iron at the bottom to sink it to the proper angle, and to have sufficient weight on the bearings to give stability to the instrument, to which it allows easy movement in rotation. The problem was to so weight the cylinder as to bring the centre of gravity of the whole instrument very close to the centre of floatation of the cylinder, so that the weight on the ball-and-socket bearing and on the pivot would be equal, as the telescope was rotated on these bearings. The cylinder with the horns was made by Messrs. Galloway, the well-known boiler-makers of Manchester, was painted outside with a mixture of white lead and tallow, and floated in the tank in a very dilute solution of caustic soda, so that the risk of freezing was reduced to a minimum.

The horns at the upper end of the cylinder are 6 feet long, and are built very strongly of $\frac{1}{2}$-inch boiler-plate, with a channel-iron girder running down to the bottom of the cylinder. To these horns very strong cast-iron trunnion-brackets were firmly bolted and the tube was carried on balls resting in these brackets. The tube itself, which is entirely of steel, consists of a strong square box at the lower end, carried between the trunnions in such a manner as to be capable of swinging through the horns to enable the telescope to be swung in declination through 180°, and a square framework of 2-inch and $1\frac{3}{4}$-inch angle steel, strongly braced and rivetted. The lower end carries the mirror and its cell, and contains the cover for the mirror ; to the upper end of the steel framework is attached a tinned-steel cylindrical tube carrying the

flat mount. This tinned-steel end is strengthened where it is bolted on to the steel framework by a wrought-iron skeleton framework inside, and is strengthened outside by four longitudinal hollow ribs of tinned steel 4 inches wide and 5 inches high, together with three similar encircling ribs.

The eye end of the telescope is a hole, on the west side of the tinned-steel cylinder, surrounded and strengthened by a strong brass ring; to this ring a brass tube carrying a focussing screw is firmly attached by binding and antagonising screws, so as to secure adjustment of the plane of the photographic plate at right angles to the optic axis of the telescope. The brass tube fits a series of adopters which enable the various accessories, to be described later, to be used on the instrument. Details of the eye end and focussing screw are shown in the drawings.

A 9-inch achromatic finder is rigidly attached to the east side of the steel framework, and a small finder of 2 inches aperture and 20 inches focal length is attached to the west side of the tinned-steel cylinder, close to the eye end of the telescope.

The driving arrangements of the instrument are exceedingly simple, although very effective. The clock is driven by $1\frac{1}{2}$ tons of weights, which are raised to the height of about 6 feet by means of suitable winding gear easily turned by hand. These weights are fixed in the grinding room in the position shown in the block plan (fig. 1). As these weights run down they communicate a simple motion of rotation to a rod running under the floor of the grinding room and observatory into the clock well of the 5-foot. This motion is communicated to spur wheels and regulated by a governor of the simple parabolic kind, the balls of lead of the governor weighing about 28 pounds each. Thus regulated, the motion is transmitted to a screw which works a tangent wheel on the shaft of the main driving screw, gearing into the sector of the usual form, that will allow the driving of the instrument for two hours. At the end of that time the sector must be turned back to its original position, this operation being readily performed by unclamping the instrument from the sector, unclamping the tangent wheel from the axis of the driving screw, and turning the driving screw by means of a handle at the end of its shaft until the sector is again in position for driving the instrument. The details of this arrangement will be readily made out from the drawings, see figs. 35, 36, 37 and 38.

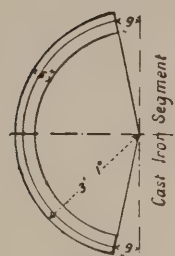


Fig. 35.

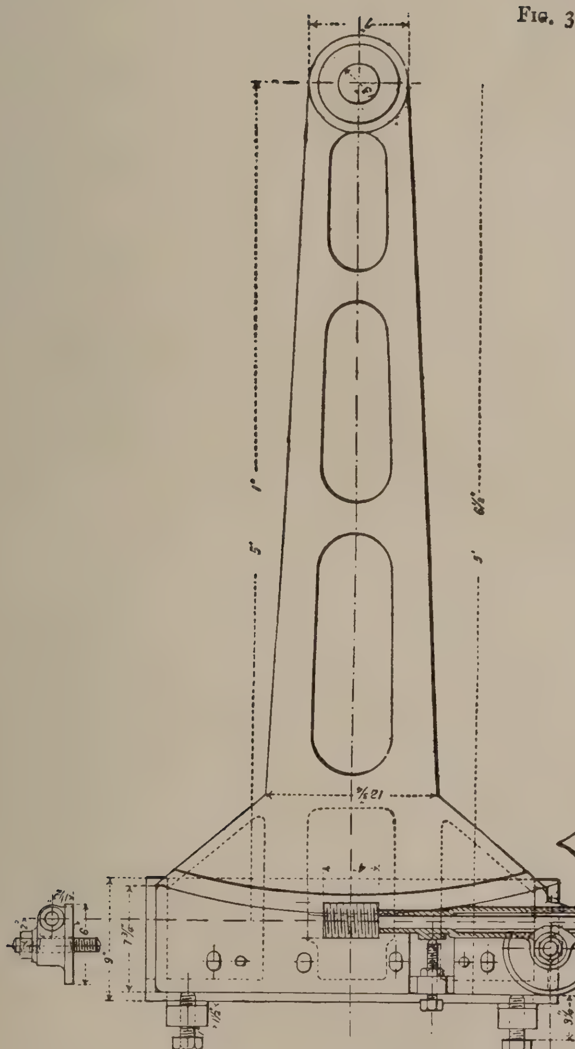


Fig. 36.

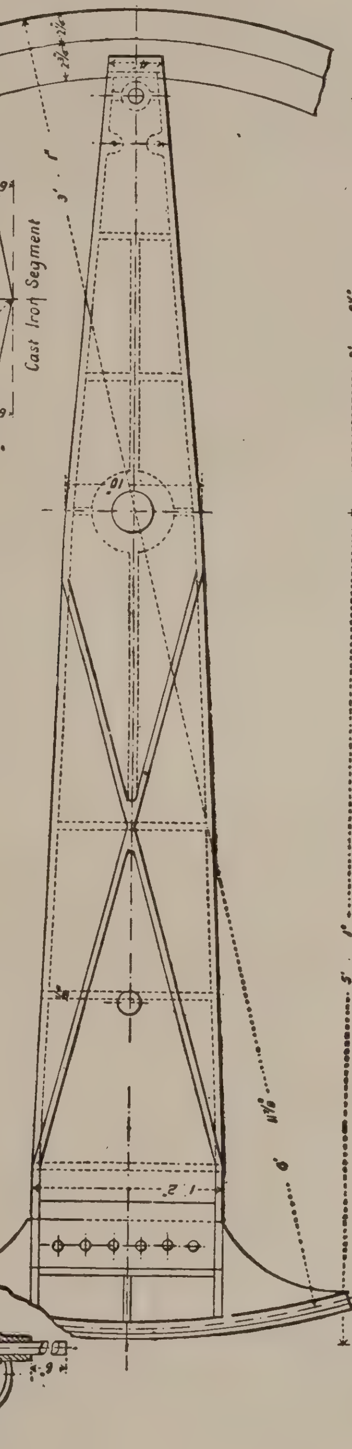


Fig. 37.

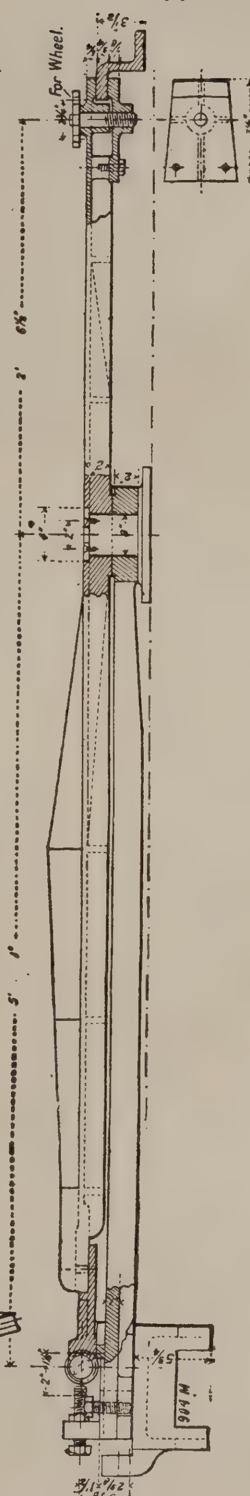


Fig. 38.

The driving sector is clamped to the polar axis in the manner shown in the drawings. A strong semicircular angle web (fig. 38) is rigidly attached to the upper end of the hollow cylinder forming the polar axis, and to this the upper end of the driving sector is clamped by a simple screw pulling a loose plate like a vice. A wheel is attached to this clamping screw, and a cord from this wheel is carried round suitable small pulleys to the eye end of the telescope, where it passes over the clamping wheels there. It is easy, therefore, by this mechanism, to clamp or unclamp the telescope in right ascension down below, or at the eye end of the tube.

The driving clock runs at the rate of eighty revolutions of the balls in a

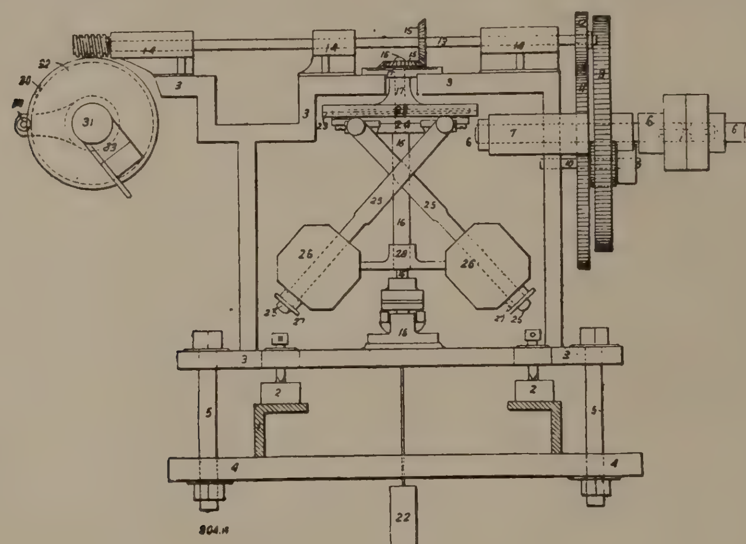


Fig. 39.

minute, and can be regulated so as to keep accurate time by alteration of the positions of the balls on the arms by means of screws. In order to secure perfect accuracy in clock driving it was originally intended to provide differential wheels for electrical regulation, and details have been worked out for such regulation. Provision for these wheels was made when the clock castings were made, but at present the wheels have not been fixed, and the clock is not altered in rate during the operation of taking a photograph. In order to secure accurately round star discs during a long exposure for photography, any slight irregularity of clock driving is at once taken up by means of a slipping piece, with watching

eyepiece, in which the photographic plate is carried; and the errors of clock driving thus detected are so small that no difficulty is found in taking up these errors by the screws of the slipping piece; hence the differential gear has not been proceeded with.

The details of the clock are shown in figs. 39, 40, and 41.

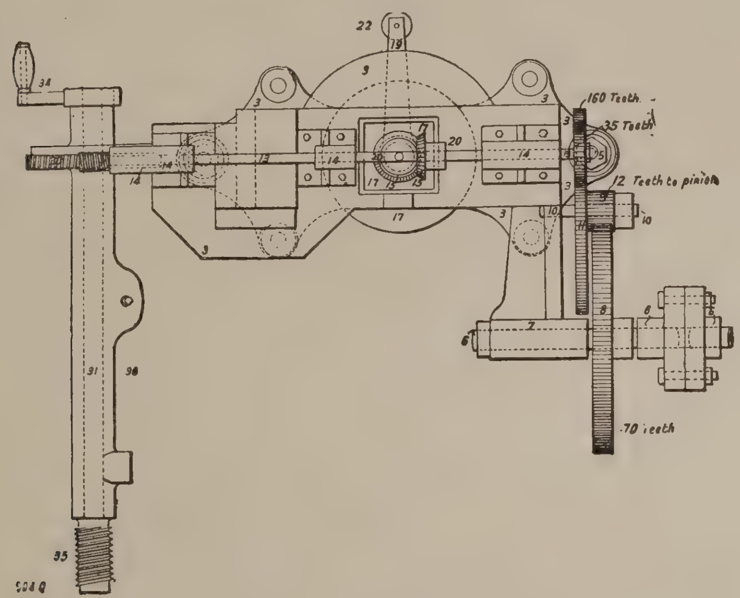


FIG. 40.

1 1 are the girders in the clock well on which the clock stands. These girders are firmly built into the wall and stretch across half the clock well.

2 2 are iron blocks resting on the girders to act as bearers of the set-screws.

3 is the cast-iron bracket of the clock. This rests on the blocks 2 2 by four set-screws (shown in the plan), and can be accurately levelled by means of these screws.

4 is a strong wood beam under the girders 1 1. The ends of the bracket 3 are bolted to this beam by means of the bolts 5 5, and the bracket is after levelling held firmly in position by means of these bolts and the beam.

6 is the driving shaft or spindle. This is rotated from the winding arrangement shown in plan on fig. 1. The rotation is communicated to this shaft or spindle in the usual way adopted for clock driving—*i.e.* by the slow fall of raised weights.

7 is the bearing of the spindle 6 ; this is part of the bracket 3.

8 is a wheel with 71 teeth on the spindle 6.

9 is a pinion with 12 teeth gearing with the wheel 8 and running on a short spindle 10.

11 is a wheel with 160 teeth on the same spindle (10) as the pinion 9.

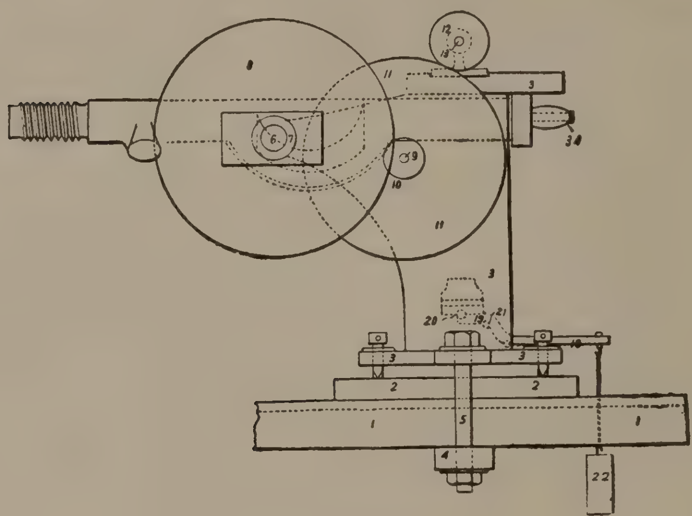


Fig. 41.

12 is a pinion of 37 teeth gearing with the wheel 11.

13 is the upper and main spindle of the clock which communicates the motion to the driving gear. This spindle has gun-metal bearings, 14, 14, 14, which are fixed to the cast-iron bracket 3.

15 are mitre wheels, each with 36 teeth. One of these is on the main spindle 13, and communicates its motion to the vertical shaft 16 of the clock governors.

16 is the spindle of the governors.

17 is a gun-metal bearing for the spindle 16. It is square above the bracket and is bolted down to it. A neck of the bearing passes

through the bracket 3 and terminates in a circular plate below. This plate is therefore fixed and practically forms part of the bracket 3.

18 is the lower bearing of the spindle 16.

The lower end of the spindle 16 is formed into a boss with a circular groove in its under side, to retain a ring of steel balls, a similar boss with groove on its upper side being below, thus forming what is known as a ball bearing.

19 is a lever with a semicircular end (see plan), the ends of which rest on two steel balls.

20 are the two steel balls similar to those used for bicycle bearings. These balls are carried in holes on the ends of the lever 19.

21 is a single ball resting in a shallow hole in the bracket 3 and in a similar shallow bearing in the under side of 19.

22 is a weight hung on to the free end of the lever 19.

This weight tends to raise the semicircular end of the lever 19, using the ball 21 as a fulcrum. Most of the weight of the spindle 16 and the heavy lead balls attached to it is thus borne by the lever 19 and the ball bearing, and is not exerted on the bearing 18 which carries the lower end of the spindle 16.

23 is a circular loose plate equal in size to the circular plate of 17 and dished slightly on its upper surface, just as the fixed plate of 17 is dished at its under surface.

The plates 23 and 17 when brought into contact by the lifting of the governor balls bring friction into play at once. This was found to act too quickly, and two knobs were attached to the lower plate that rest on springs, so that the retarding effect is brought gradually to bear.

24 is the main arch of the governors, and this is firmly keyed to the spindle 16.

25 are the crossed arms of the governor carrying the heavy lead balls at their lower ends.

26 are the heavy lead balls of the governor, each weighing about 28 lbs. The positions of these on the arms 25 can be regulated by means

of the nuts 27 which are screwed on to the tapped ends of the arms.

28 is a bracket with two arms keyed on to the spindle 16 and arranged to support the governor balls when the clock is not running, but of such length that as soon as the clock is started the balls are always raised off these supports when the rate is normal.

The upper ends of the arms 25 are pivoted to the main arch 24 of the governor in such a manner that when the spindle 16 rotates, and the governor balls rotating with it are raised off their supports by the centrifugal force, then the upper portions of the arms 25 are pressed against the loose plate 23, and this being thus placed in contact with the circular plate 17 acts as a brake upon the rotating governor balls.

The balls cannot rotate without carrying the loose plate with them. The rate of rotation of the loose plate is regulated by its friction against the fixed plate 17, and by altering the amount of friction between these the rate of the clock can be adjusted. Raising the balls on the arms tends to increase the rate of rotation of the combination, but the tendency to increase of rate raises the loose plate and increases the friction. Any irregularities of strength of driving power do not alter the rate of the clock, but simply increase the friction of the two plates.

29 is a tangent screw on the end of the spindle 13.

30 is a tangent wheel with teeth running loose on the spindle 31.

32 is a circular plate rigidly fixed to the spindle 31.

33 is the bearing of the spindle 31; and this bearing is firmly bolted down to the iron plate I of the brick tank shown on fig. 43.

34 is a handle, also securely keyed on to the spindle 31.

The main spindle of the clock, 13, in rotation causes the tangent screw 29 to drive the tangent wheel 30, which runs free on the spindle 31.

The circular plate 32 can be fixed to 30 by means of a key which passes through a hole in 32 and screws into one of a series of holes in 30. Rotation of the main spindle 13 is regulated, therefore, by the clock governor through the mitre wheels 15, and is communicated to the spindle 31 by means of the tangent wheel 30 and the disc 32. It is thus transferred to 35, which is the

driving screw of the clock, and gears with the tangent thread on the sector shown in figs. 36 and 37.

The movement of the telescope in declination is given by swinging the tube on the trunnions carried on the horns of the polar axis. The positions of these trunnions are shown in fig. 43, and it will be sufficient, therefore, to say that the cups borne on the horns and the covers for them are $\frac{1}{2}$ inch greater in diameter than the balls attached to the tube, the space between the two being filled in accurately with white metal, so as to give a perfect bearing-surface and reduce friction. This arrangement,

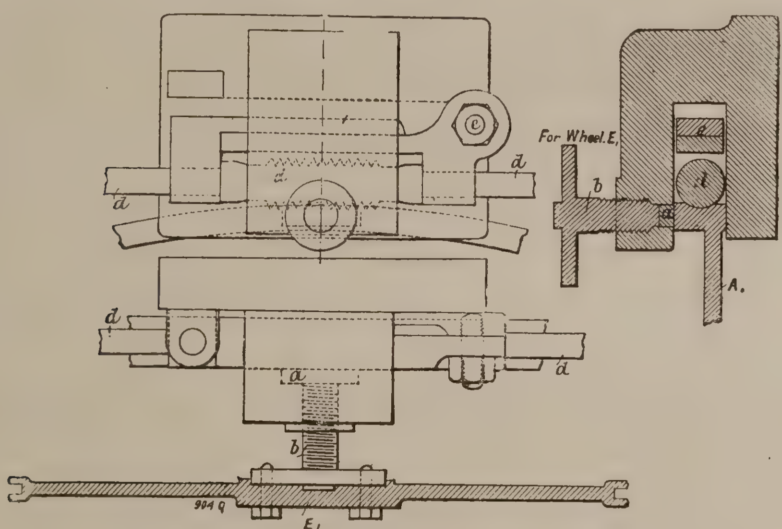


FIG. 42.

with tallow as a lubricant, gives a perfect bearing, and, although the instrument has been in use for over three years, no error of position of declination axis has been developed.

From the elevation of the telescope it will be seen that for 210° around the trunnion a large declination sector is firmly fixed to the horn of the polar axis; this sector serves the dual purpose of affording a means of clamping the telescope in declination and of giving a definite slow motion on declination.

The clamping is arranged by means of a bracket attached to the tube of the telescope. This bracket loosely fits the rim of the sector and moves freely over it, see fig. 42. A loose block, *a*, in the bracket is capable of being

pressed, by means of a screw *b*, firmly on to the rim of the sector A_1, and this screw is actuated by means of a wheel E that is connected by a cord with a similar wheel at the eye end of the telescope. The clamping or unclamping of the telescope in declination is easily performed, therefore, at this screw or from the eye end, and the movements of the whole instrument are under perfect control by the observer.

The edge of the sector A_1 is cut into teeth which engage with an endless screw *d* attached to the clamping bracket. By means of a handle at the end of the screw *d* a movement of rotation given to it moves the sector A_1 and thus moves the telescope in declination; the size of the teeth in the wheel being such that one rotation of the handle moves the telescope half a degree in declination. It was designed originally for this slow motion to be carried up to the eye end by means of a strong tube; but this addition to the mounting has not yet been made. By means of the pivoted bar *e*, the screw *d* can be disengaged from the sector A_1 so that the telescope can move independently of the tangent screw, and be clamped or unclamped by means of the screw *b* acting on the block *a*. When *d* is geared with A_1 the telescope can only be moved in declination by rotating the tangent screw *d*. The balance in declination is so good and the telescope is moved so easily from the eye end that the tangent screw *d* has been removed to allow free movement.

Fig. 43.

This is a section of the telescope and tank, showing the details of the mounting.

A is the brick tank, shown in plan on fig. 1. Its sides are 15-inch brickwork, and it is lined inside with Portland cement. The tank is dug out of the solid clay, and up to the present time has been found absolutely water-tight. The southern end of the tank is built straight up from the bottom of the pit, whereas the northern end of it is inclined at an angle of 51° 30′, equal to the latitude of the place.

B, at the north of the tank, is another well, in which the driving clock of the telescope is fixed.

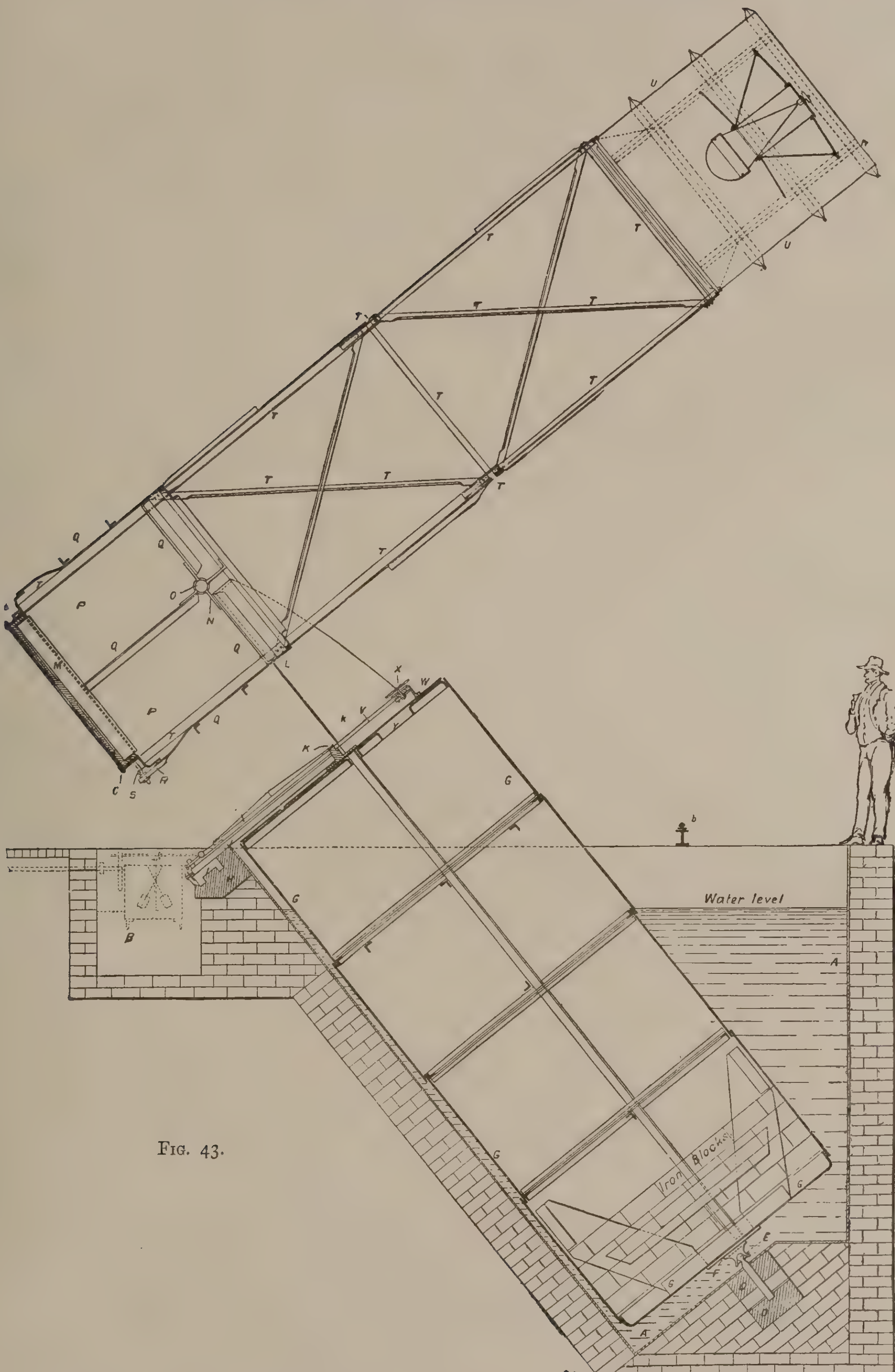


Fig. 43.

D D, at the bottom of the tank, are two stone blocks set in the brickwork.

E is a steel pin firmly set in the stone blocks D D, and terminating in its free end in a ball.

F is a gun-metal socket which accurately fits the ball E.

G is the polar axis of the telescope. This is a boiler or closed cylindrical tube, built up of $\frac{3}{8}$-inch boiler-plate and firmly braced inside by means of angle irons. It is specially strengthened at the lower end by the stays shown, and contains the iron blocks for sinking to the required angle. The socket F is firmly bolted to the polar axis, so that the lower end of the axis is supported on the steel pin E, and is capable of rotation on that support.

H is a stone block, firmly set in brick and concrete at the upper end of the brick tank A.

I is a strong iron frame or girder firmly set into the block H.

J is a cast-iron bracket bolted down to I.

K is a steel pin forming the upper central bearing of the polar axis G, and this pin rests in a bearing of the bracket J.

H I J K, therefore, form the upper support of the polar axis. The central line of the polar axis passes exactly through the central line of the pins E and K. This is placed exactly in the meridian, and exactly at the right inclination, by means of adjusting screws which act upon the lower portion of J. The holes through which the bolts pass to fix J down to the girder I are slotted (see fig. 35) so as to allow the adjustments to be made. When the polar axis is exactly in adjustment, the clamping of J to I fixes the positions of the bearing K. The polar axis is thus capable of rotation on the bearings E F (which form practically a ball-and-socket joint) and the bearing J K.

L is one of two horns. These are projections of the upper portion of the polar axis, and are built up of strong $\frac{3}{8}$-inch boiler-plate. The amount of rotation of the polar axis is limited by these horns to a little over 180°, but as this allows an equatorial star to be followed from its time of rising to its setting without any reversal of the telescope, they have not been found to present any difficulties in actual working.

M in this, as in all the other drawings, is the mirror, and C is the bell.

N is one of the trunnions lined with white metal. The upper ends of the horns terminate in trunnions, and the central line of the polar axis is in the same plane, and exactly at right angles to the line joining the centres of these trunnions.

O is a ball which exactly fits into the trunnion N.

P is the square iron end of the telescope tube, and is made of $\frac{5}{8}$ boiler-plates firmly bolted together. The inside is strengthened by angle irons Q, to which the ball O is rigidly attached, so that the trunnions N carry the whole of the tube by the bearings O, and the short end P is capable of swinging through the horns L.

R is a bracket attached to the lower portion of the tube P, and carrying a hinge.

S, by means of which the cell C can be attached to the tube P, and the mirror M and cell C raised into the positions shown in the drawing. The method of attaching the cell C to the tube P will be easily seen from figs. 25, 26, and 27, which show the cell C on a larger scale, together with the details of mounting of the mirror M in the cell C.

Fig. 31 shows the hinge S, with the bracket R in detail.

Figs. 28, 29, and 30 show the cover of the mirror M. This cover is arranged in P, and can be raised so as to rest against M, or lowered on to the bottom of the tube P when required, by means of the apparatus shown in detail in those drawings. The silk flap, also shown on fig. 28, is in the tube P, and when the mirror cover is lowered on to the bottom of the tube, the silk flap is dropped over it to prevent dewing of the cover-glass, and to avoid internal reflections in the tube.

T T T is the skeleton framework of the telescope tube, firmly attached to the iron box P, and passing right into it at its lower end. It is built up of $1\frac{1}{2}''$ angle iron, rivetted together in the manner shown in this and on fig. 44.

The framework T T is square in section, and when each of the eight panels is filled in with a wooden framework covered with black canvas, the tube thus formed is practically light-tight, is very strong and remarkably free from flexure, while, owing to its light

construction and the small quantity of metal used, there are very few irregularities of the air in the tube during observations.

U U U is the tinned-steel eye end of the tube carrying the flat mount. This is shown in detail in figs. 32, 33, and 34, and further description here is unnecessary.

V V is the driving sector of the telescope. This is shown in detail on figs. 25, 26, 27, and 28.

W is the clamping bracket of the polar axis. This is also shown in detail on figs. 26, 27, and 28. It is firmly bolted down to the polar axis G—in fact, forms part of it and shares all its motions.

X is the clamping wheel for Right Ascension.

Y is a man-hole in the upper part of the polar axis G, to allow the weight at the bottom of G to be got at and altered if necessary, so as to allow any alterations in the balance of the telescope.

a is the brick curb for the circular rail *b*.

These latter are shown in plan on fig. 1, where the plan of the house or covering is indicated.

Fig. 44.

This shows an elevation of the telescope, an elevation of the observing stage, and a section of the house or covering of the telescope. The western side of the house is supposed to be cut off, so as to show the interior, the telescope and observing stage being seen in western elevation. A line X Y on fig. 1 illustrates the line of section.

C is the cell of the mirror, S being the hinge and R the bracket supporting the hinge to the iron box P, which forms the lower end of the tube of the telescope.

T is the skeleton tube and U is the tinned-steel eye end, exactly as on the sheet 9.

G is the polar axis, showing L the western horn, surmounted by N the trunnion, in which a ball from P rests. W is the clamping bracket, X the clamping wheel, and V is the driving sector of the telescope, J being the strong iron bracket, with the bearing K, which forms the upper support of the polar axis G. All these can be recognised shown in section in fig. 43.

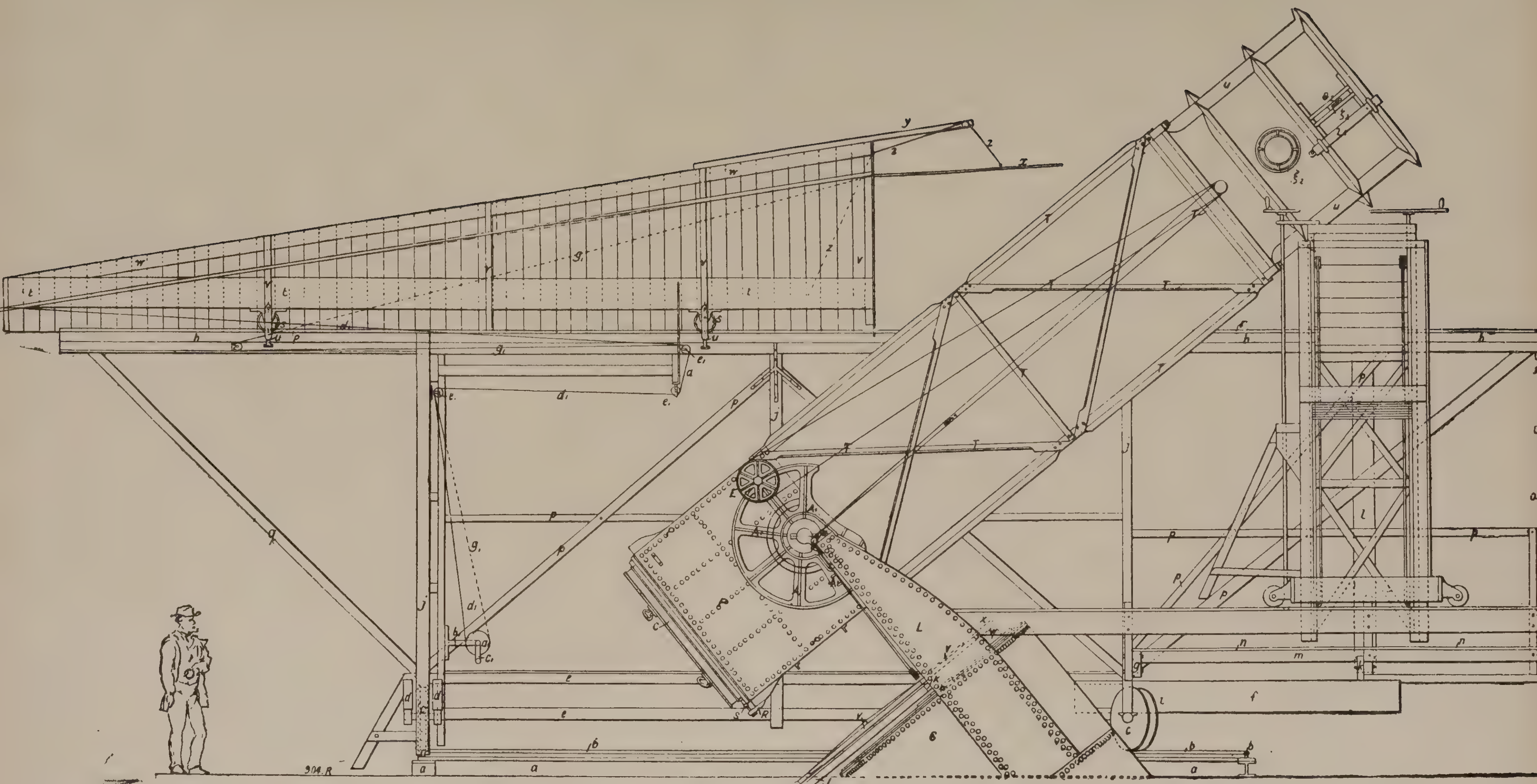


FIG. 44.

a is the brick circular curb carrying the rail *b*, on which the house is rotated.

c c are two of the three wheels on which the house is built. The north wheel is seen between the two strong beams *d d*, and *e e* is the eastern side beam that extends from *d* towards the second wheel, which is seen in elevation.

g is the beam that joins *e* to a similar beam *e* on the opposite side of the house, the beams *d d*, *e e*, and *g*, shown in plan on fig. 1 and in section and elevation on this figure, forming a square framework, on which the whole house is constructed.

f is one of the two beams that are firmly bolted to *e* and *g* and project out to the south of *g* (see plan) to form the cantilever on which the south end of the house is carried. The wheel *c*, shown in elevation, is placed at the corner formed by *e* and *g*, and is between *f* and *i*, the latter being a smaller beam parallel to *f* and sufficiently separated from it to enable the wheel *c* to rotate freely between them.

h is the upper beam of the house, on which the rail carrying the roof is laid. All these can be recognised on fig. 1, where they are shown in plan.

The new lettering adopted is as follows :—

A_1 is the declination sector, which has the double purpose of serving as clamping sector, and for giving a slow motion in declination. The sector A_1 is really part of the horn L, for it is rigidly bolted to that. It extends all round the trunnion N, its outer edge including an angle of 210°. It is made of cast iron strongly ribbed and webbed, to give rigidity. Its outer edge has teeth cut in it, each tooth covering exactly half a degree of declination.

B_1 is the declination circle screwed on to the sector A_1.

D_1 is the reader for the declination circle. This is attached to the horn L of the polar axis, and moves with it, a wire in the eyepiece of the reader being carried over the divisions on the declination circle, so as to give the declination of the object to which the telescope is pointed. The declination in the drawing is 0°.

E_1 is the wheel of the declination clamp, and a cord from this extends up to the eye end, U, of the telescope, passing there round a wheel H_1, which is within reach of the observer at all times.

F_1 is the declination clamp, which is rigidly fixed to P, and slides accurately over the edge of the sector A_1. Details of this clamp are shown in the drawing, fig. 42. By means of the wheel E_1, the clamp can be made to lightly clip A_1, and the telescope is then fixed in declination, since A_1 is part of the polar axis, which never varies.

I_1 is a tangent screw with a rod and handle, J_1, that is attached to P. The screw I_1 gears with the edge of sector A_1. One rotation of the handle J_1 moves the telescope up or down in declination half a degree. The instrument is always clamped when this screw is in gear with the teeth of the sector A_1, but the screw can be put in or out of gear very readily by means of a pin, which enables the handle and rod J_1 to be raised or depressed at any time.

K_1 is a clamping cord which passes from the wheel χ of the right-ascension clamp to the wheel L_1, near the eye end of the telescope, being carried on suitable pulleys from χ, up the side of L, to the pulley L_1, within reach of the observer.

The finder i_2, the eye end fitting λ_2, μ_2, and the focussing wheel ξ_2 can be easily recognised on this drawing as they are shown on fig. 34.

θ_2 is angle iron supporting the bearing of the screw which regulates the position of the flat cover shown on fig. 34. The handle ξ_2 can also be seen.

The section of the house shows many features not indicated in the plan on fig. 1. Continuing the lettering adopted, we have *j*, *j*, *j*, uprights firmly bolted to the framework *d*, *e*, *g*, referred to, and supporting the northern portion of the upper beam *h*.

k is a beam which rests on the cantilever *f*, and supports at its ends the uprights *l*, that also help to carry the beam *h*.

m are joists that are fixed to *g* and *k*, and support the floor, *n*, laid upon them.

o is an upright fastened to the most eastern of the joists m, and serving as another support for the end of the beam h.

The beam h is thus supported along the whole length of the house by the uprights $j\ j\ j\ l\ o$. These uprights are fastened together by cross braces and struts, all of which are indicated as p.

q is a strut serving to support the northern end of h, which projects beyond the house, so as to carry the roof.

r is the rail, laid the whole length of h, on which the roof rollers run.

$s\ s$ are the roof rollers, running in the rail r.

t is the eastern main beam of the roof, running on the two rollers $s\ s$.

u are safety guides, or catches, which clear h and allow the roof to run smoothly on the rails, but would, by pressing against h, prevent the roof being blown off or forced off the rails.

$v\ v\ v\ v$ are uprights from the main beam t of the roof, which carry the upper beam w on which the corrugated iron is fixed. The cross bracing of the roof is not shown fully.

x is a shutter on the front of the roof, which, when raised, enables the roof to pass the observing stage when running the roof off the house or replacing it when observations are concluded.

y is a single projecting beam on the western side of the roof immediately over the centre of the shutter. This carries a pulley, over which a cord z passes, and by means of this cord the flap or shutter x can be raised or lowered as required.

a_1 is a winding barrel, attached to the northern side of the house by means of the strong bracket b_1.

c_1 is the handle of the winding barrel.

d_1 is a cord which passes round the barrel a_1, round suitable pulleys e_1 to the end of the roof at f_1. Rotating the handle shortens this cord and pulls the roof along on the rollers until the telescope is covered and the front of the roof x is brought up level with o. At the time d_1 is shortened, a similar cord g_1, that is attached to the front of the roof at h_1, is lengthened, or wound off the winding barrel. The covering of the house is effected by shortening d_1 and lengthening g_1; the uncovering of the house is effected by the

reverse operation. Both cords being wound on the same barrel are altered at the same rate, and the roof can be moved on or off by simple rotation of the barrel a_1, by means of the handle c_1.

IX.

Accessories.

Under this heading I have classed the circles of the telescope, the eye end with focussing arrangements, the photographic apparatus for ordinary photography, for lunar photography and for enlargements, the spectroscopes and the micrometer.

The circles are extremely simple, being merely used for finding or identifying objects and not for accurate determinations of position. The declination circle is divided to 10′ of arc and each degree is separately numbered. It is attached to the west side of the tube round the trunnion, and a low power microscope with a wire in the focus of the eyepiece serves to read the circle. This reading microscope is fixed to the west horn of the polar axis, and the declination circle moves under it as the telescope is raised or depressed. With this simple arrangement and with the circles divided to 10′ it is possible to fix declination to 2′ with great ease, and as the field of the telescope covers 1° in declination no difficulty is found in identifying any object sought for.

The R.A. circle is simply a row of figures painted round the body of the polar axis. The circumference of the cylinder which forms the polar axis is 24 feet, so that one hour is represented by a foot and divisions to four minutes of time by $\frac{4}{5}$ of an inch. An iron upright attached to the floor at the side of the polar axis carries a fixed mark, and hour angles E. or W. of the meridian are readily ascertained with sufficient accuracy for the purpose mentioned.

The eye end of the telescope was designed for photographic work, being specially large, so as to allow one clear degree square to be photographed on the plate. The focal length of the mirror being 27 feet, a 6-inch square plate covers a little more than one square degree at the focal plane. An aperture of $8\frac{1}{2}$ inches was therefore allowed at the eye end, so that there is a

margin all round the plate to allow for movements of the plate-carrier by a slipping piece during the long exposures necessary for nebular photography. Errors from clock driving and the changes of apparent declination due to refraction are taken up at once during the exposure, a close watch being kept on a guide star at the edge of the field which is being photographed. A full description of this special apparatus is given with illustrations in Vol. XLIX. pp. 297–300 of the *Monthly Notices*, and I have thought it advisable to reproduce that description here. Fig. 45 is from a photograph of the apparatus with the plate-carrier detached.

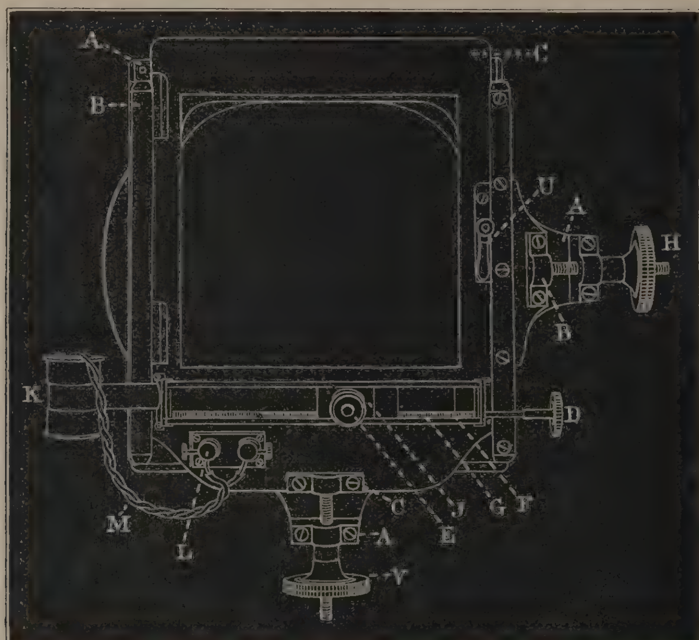


Fig. 45.

A A A is a plate with three clips behind to attach it rigidly to the eye end of the telescope.

B B is a slide fitting into A and capable of movement in a horizontal direction by means of the fine screw at H.

C C is a slide fitting into B and capable of movement in a direction at right angles to the movement of B by means of the fine screw at V.

The dark slide is fitted on to the plate C, a small cam, U, serving to fix

the dark slide in position. D is the milled head of a fine screw F, extending the whole length of the box G, the latter being part of the slide C, and having a glass face.

The plate J slides in grooves above the glass face, and has the eyepiece E screwed into it.

On F is fitted a nut, carrying a small ring (under the glass face) with two cross-wires, the intersection of which is exactly in the focus of E, and also in the plane of the film of the photographic plate. The cross-wires are illuminated from the side by a small incandescent lamp in K, the light being steady and uniform when the current is supplied from one or two storage cells to the screws L and thence through M to the lamp.

Any one of a line of small pinholes through the bottom of the box G can be uncovered and the cross-wires and eyepiece brought directly over it. Unless the uncovered pinhole is very small there will be danger of light getting through it and on to the photographic plate, the faintest external light falling on the plate for two or three hours being sufficient to fog it.

A section of the eye end showing the focussing arrangement is given in fig. 47. A is the tinned-steel telescope tube with a strengthening ring B of brass, round the opening for the edge end.

N is a brass ring screwing on to B and holding down the flange of the tube C. The tube C is capable of rotation by means of the focussing wheel O, and on the interior of C a thread is cut which engages with a similar thread cut on the outside of the tube D. The turning of the focussing wheel O moves the tube D in or out of the tube C, and thus regulates the position with regard to the focal plane of the telescope of anything attached to D. To the flange of D a strong flanged brass ring is attached by means of three binding screws, one of which is shown at E, and the front of this ring carries the slipping piece F which carries the supporting plate for the spectroscope or enlarging camera.

For Moon photographs at the principal focus of the telescope a special arrangement has been devised to give very rapid exposures, and also longer exposure to the termination than to the limb. This apparatus is shown in section and elevation, fig. 46.

An adapter tube (1) fits into the eye end of the telescope, the outer end of the adapter being closed by a plate with a circular hole four inches

diameter in it. Three studs (2) screwed into this plate serve to support the plate-carrier, and two other studs (3) serve for guides in placing the plates' register. A movable arm (4) is also carried by the front plate of the adapter,

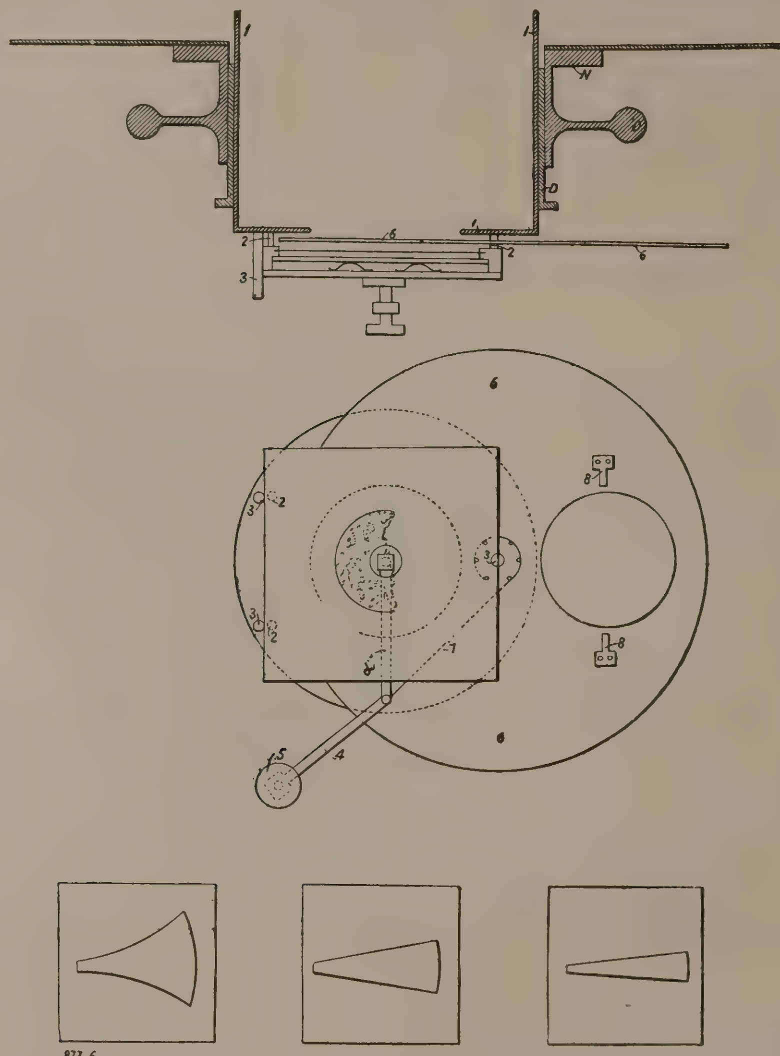


Fig. 46.

and this arm can be moved up to the position shown by the dotted lines 4*a*, the plate-carrier being pressed firmly on to the studs by the screw (5). One of the supporting studs for the plate-carrier acts as a pivot for a thin circular plate of brass (with a hole in it), which acts as the exposing-shutter (6),

and can be rotated close *under* the photographic plate. The rotation of this shutter is produced by the action of an india-rubber spring (7), which can be tightened at will to vary the exposure. Over the hole of the exposing-shutter any one of a number of diaphragms of thin sheet tinned-steel can be fixed by means of the spring clips (8), and by altering the shape of the openings in these diaphragms any required difference in exposure for the terminator as compared with the limb can be obtained.

Rapidity of exposure seems to offer in the case of the Moon a greater chance of sharpness and detail than any other means, for the atmospheric tremor becomes painfully evident on an examination of the image of the Moon in the enlarging apparatus described later on. In the case of a rotating-shutter such as I have used, an equal exposure all over the Moon would be given by a sector with radial sides. It is necessary, however, that the terminator should have such an exposure as will not hopelessly over-expose the bright limb, and a modification of the shape of the opening will do this. The apparatus shown in the figures is placed with the terminator towards the centre of the exposing-shutter, and the shape of the opening in the diaphragm is somewhat like a reversed sector with curved sides.

Three spectroscopes are used on the 5-foot telescope. An ordinary McClean direct vision spectroscope fits into the eyepiece adapter, and is used for making rapid surveys.

The prism star spectroscope has a collimator lens and object-glass of 1 inch aperture and $5\frac{1}{2}$ inches focal length. Two prisms of 30°-angle and one of 60° are used, the 30° prisms being attached to the collimator lens, and the object-glass of the observing telescope with one of their sides normal to the optic axes of the lenses. The principle is shown in fig. 47, the 60° prism being fixed between the two 30° prisms as shown and adjusted for minimum deviation. The observing telescope is rigidly attached to the base plate of the spectroscope, and an automatic attachment to the 60° prism and the collimator always keeps the prisms adjusted at the angle of minimum deviation, whether the instrument is used for photographic work or for eye observations. Two eyepieces are used with magnifying powers of 5 and 15. The photographic apparatus is attached to the spectroscope by removing a portion of the observing telescope and inserting the camera tube. The camera is leather, and is provided with the usual swing back, supported on a

pin, fitting into a slot in the base plate, and fixed by a screw when adjusted for photography. The length of the photographed solar spectrum is a little over half an inch on ordinary plates, and nearly three-quarters of an inch on orthochromatic plates. The dark slide is of metal.

The peculiarities of the instrument are (1) an arrangement for covering or uncovering the slit at will, two small pivoted shutters being provided; one of these covers the central portion, and leaves the top and bottom open, while the other covers the top and bottom of the slit, and leaves the centre.

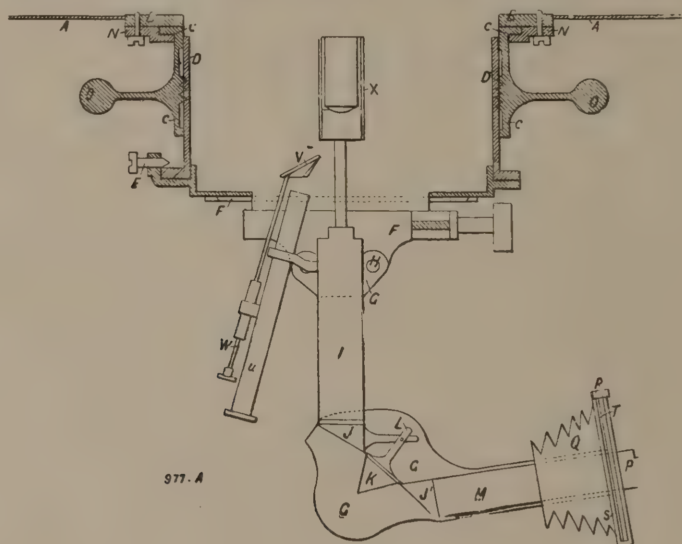


Fig. 47.

This arrangement allows a star or nebula spectrum to be photographed in the centre of the plate with a comparison spectrum above and below, a small overlap being allowed to assist in the identification of the lines.

(2) At the side of the collimator a small watching telescope is arranged with a reflecting prism in front, and so arranged that the slit can be watched during the whole of the exposure, all errors of clock run, and the refraction correction being made by means of a strong slipping-piece, which forms the front of the adapter carrying the spectroscope. The details of this arrangement can be made out by reference to fig. 47. G is the base plate of the spectroscope firmly attached to the slipping-piece, F, by two screws at H. I is the collimator with a 30° prism, J, over the lens. A similar prism, J′, covers the object-glass of the observing telescope, M. K is the 60° prism,

L being the automatic attachments of K and I by means of which the prisms are always kept at minimum deviation. P is the observing eyepiece fitting into M for eye observations, while Q is a camera similarly fitting into M, and interchangeable with the eyepiece adapter, P.

R is the dark slide with the shutter (S) closed in front of the photographic plate, T.

U is the watching eyepiece, in which the slit of the collimator, I, is watched by means of the prism V, the position of which is regulated by the screw, W. X is the cylindrical lens attachment.

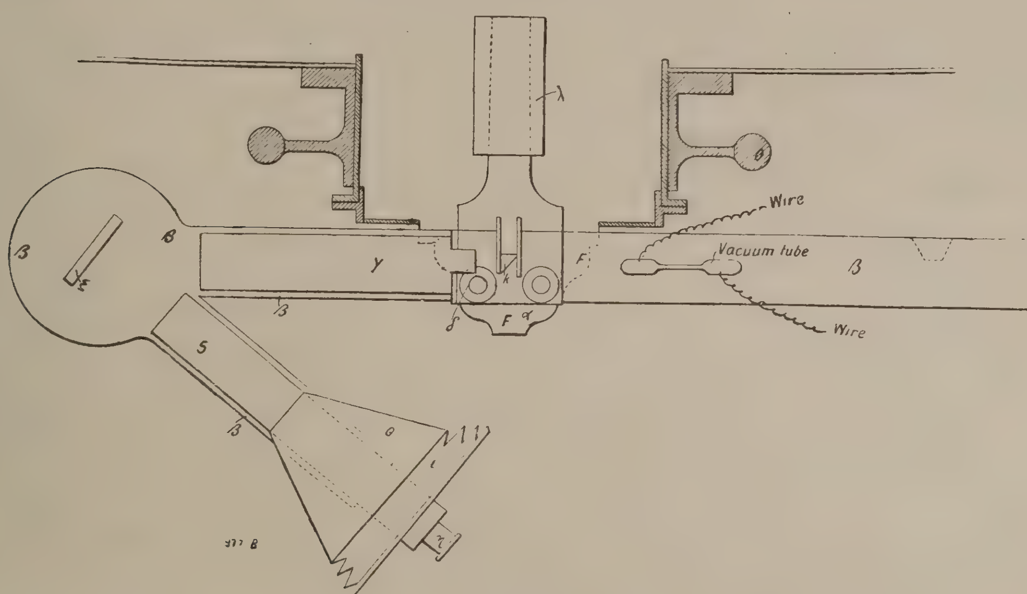


FIG. 48.

The grating spectroscope (fig. 48) has a collimator lens of $1\frac{1}{2}$ inch aperture and 8·6 inches focus, with an observing telescope of the same size. The grating is 2 inches square, and was made by Rowland, being ruled 14,438 lines to the inch. The collimator and observing telescope are fixed; the grating is rotated so as to give the required order of spectrum. The spectroscope is carried on a slipping-piece (F), as with the other spectroscope, and is so attached that the optic axis of the instrument is parallel to the optic axis of the mirror, and therefore at right angles to the emerged beam from the telescope. This beam is received on a small right angled prism, and reflected on to the slit of the spectroscope.

This arrangement has many advantages. The slit is always accessible, and can be watched throughout the exposure, so that the star need never leave it. Comparison spectra are easily obtained, the spectroscope, except when the small prism is in place, being practically independent of the telescope. The observer is in the best possible position for viewing the spectrum during eyework, the telescope tube being very much in the way if the ordinary method of attachment is adopted for a reflector. By prolonging the base plate beyond the points of attachment to the slipping-piece, counterbalance weights can be attached, and strains in the spectroscope due to its weight and its changes of position minimised.

F is the slipping-piece to which the spectroscope is attached by means of the bolts α, the long plate β acting as base plate of the spectroscope; γ is the collimator, with the slit at δ; ϵ is the grating; ζ is the observing telescope, fitted either with the observing eyepiece η or the camera θ, with swing back ι; κ is the small right angle prism which receives the light through the cylindrical lens at λ.

The photographic enlarging apparatus is simply a box camera, with the secondary magnifier in place of the ordinary lens. The camera is attached to the slipping-piece used for carrying the spectroscopes, and a small eyepiece at the back of the camera enables a star in the field of view of the enlarging lens to be watched during the long exposures necessary for star clusters and other faint objects. The exposure is made by uncovering the secondary magnifier in the way usually adopted for ordinary photographic work.

The ordinary photographic slipping-piece can carry a strong metal plate in place of the usual dark slide; and an adapter tube is fixed in the centre of this plate to carry the eyepiece for visual work.

The micrometer is of the usual form used for double star work, but the spider lines in the field are illuminated from the side by means of a small electric lamp. Bright wires on a dark field are preferred for nebula observations. A small occulting disc is attached to the frame carrying the spider lines, thus enabling faint stars and satellites to be observed and measured in a field containing a bright star or a planet.

The house is lit by three 8-candle power electric lights, and a separate main is led to the eye end of the telescope from two of the storage cells, so as to illuminate the cross wires of the photographic slipping-piece or of the

micrometer. The great advantage of the use of these small lamps, which never require trimming and never go out, can only be properly appreciated by one who, like myself, has worked with the old oil lamps.

X.

The House.

The house or covering of the telescope, and the observing platform on which the observer works, are very simple in construction, and up to the present they have been found very efficient in operation.

The great expense of a dome of sufficient size to cover the 5-foot telescope prevented me from considering the possibility of that kind of covering. The construction of a portion of a dome would also have presented difficulties as regards size and expense, and I determined to adopt a simple house, similar to that used for the 3-foot telescope.

The whole house turns on a circular rail, carried on a solid foundation of brickwork 23 feet in diameter. Three double-flanged wheels, each 2 feet in diameter and 4 inches wide, were made to run on this rail, and on these a pentagon of wood was built, one wheel being in the middle of the base, and the other wheels at the two sides of the pentagon that are farthest from the base, and therefore form the apex of the pentagonal frame. This wooden framework was firmly braced together, so that it would be rigid when weighted in any part, and would run freely on the rail. A strongly braced framework was then built up on the pentagon, the sides sloping outwards to cover and protect the floor within the rail, while the apex of the pentagonal framework carried a square platform just as wide as the sides of the house. The result of this arrangement is that the house appears in plan as a long rectangular building with two wings on the northern portion of the east and west sides. The south end is a cantilever carried on the two short arms of the pentagon. The telescope is at the centre of the circle marked out by the rails. The roof of the house covers in the whole of the structure when pulled on, but before observations are commenced it is run off (on four rollers running in straight rails) until the south portion of the house is clear of the centre of the circle of the rail, the north end of the roof being carried on brackets projecting from the main supports of the house.

When the roof is off the telescope is free to swing up to the zenith without touching the house in any part. The movement of the telescope in Right Ascension would bring it into contact with the sides of the observatory, but the house can be rotated on the circular rail as the telescope moves, and thus any portion of the heavens examined, for it is possible with this kind of house to place the telescope pointing to the zenith and rotate the house 180°, and then swinging the mirror end of the tube through the horns of the polar axis to work below the pole.

The general idea of the observing platform was founded on the compound slide-rest of a lathe. Rails were laid on strong beams running along the sides of the house, and on these a motion of the platform to and from the telescope was made. Two beams carried on these first rails extended across the house from side to side, and on these a motion in azimuth could be given to the platform. It was decided to abolish these cross beams, the motion in azimuth of the platform being always so easily secured by the motion of the whole house. The observing platform itself consists of a square framework into which a smaller framework is fitted, which latter can be raised or lowered at will in the outer and larger frame. The observer on the platform can, by means of handles, move the platform alongside of the telescope, or can raise or lower it, so as to be always within easy distance of the eye end; but all his movements in azimuth, rendered necessary by the movement in Right Ascension of the telescope, must be made by rotating the house. The inner frame carrying the observer is counterpoised to move easily, a clamping arrangement keeping the platform at any desired level when more than one person is on it.

Wires from a battery of storage cells are brought into the house, and electric lamps are provided at the north, east, and west sides of the house. Other wires are taken to the eye end of the telescope for lighting a small lamp for the micrometer from one, two, or three of the cells.

In the plan of the house, fig. 1.

a is the brick circle on which the circular rail *b* is laid.
b is the circular rail.
c are three wheels, 2 feet in diameter, and 4 inches wide, running on the circular rail.

d e f and *g* form the framework of the house to which the wheels are attached. The framework rotates freely on the circular rail by means of a simple mechanical gearing applied to the south-east wheel.

h are the upper beams of the house, and are supported on the framework *d e f g* by means of uprights not visible in the plan.

These beams extend the whole length of the house, and are carried on the south side by the cantilever that is formed by the beams *f*, which project beyond the wheels *c*. On the north side these beams project beyond the framework of the house, and are supported in the manner shown in fig. 44. To these long beams the rails on which the sliding roof is carried are fixed. The cross-bracing of the house is not shown in this plan, only essential particulars being introduced.

The sides of the house slope from the upper rails to the ground towards the east and west, and the testing of the mirror, when in the grinding shop, is not interfered with by the east side of the house, although that would appear to be the case from the plan.

XI.

General Remarks.

Some account of the performance of the 5-foot will naturally be looked for here. As far as I am able to judge from the use of other mirrors of considerable size the gain has been maintained, and the power of the 5-foot over that of the 18-inch and 3-foot is proportionate to the size. On nebulæ this is seen to great advantage, both visually and photographically. Such an object as *Mimas*, which the 18-inch telescope would, under the most favourable conditions, just render visible and the 3-foot show fairly well, can with the 5-foot be seen close to the end of the ring, and away from it could not be overlooked. In all such tests the gain in power is evident. For such objects as the planets the great aperture, in proportion to the focal length of the reflector as now made, gives too much light for the definition obtainable on ordinary observing nights ; for such purposes a ratio of focal length approaching that required for the refractor would be much more satisfactory in many ways.

In photography I am strongly of opinion that, however one may shorten the time of exposure by increasing the sensitiveness of the plate, that photograph will be the best which is exposed for the shortest time, for the deformation of the image due to atmospheric tremor will be reduced proportionately; and in that respect it is necessary to have a large aperture in proportion to the focal length; but for work which does not include photography and spectroscopy I should certainly have a ratio of, say, 15 to 1. Such a mirror of large aperture, properly mounted for visual work, would be the finest optical instrument possible.

I consider it an extremely fortunate circumstance that the first mirror gave such a very bad image that it had to be condemned, and another disc of glass made. Had it been just passably good, it is more than probable that I should not have made another, but should have come to the conclusion that the limit of useful size had been reached. It is possible that other mirrors may have a defect similar to the first disc, due to the same cause. From these that perfection of figure that is possible with the reflector cannot be obtained. The tests at the centre of curvature fortunately give the means of determining this point.

I am not quite sure that a mirror gives absolutely at all times the same results in the telescope which the tests made indicate that it should. With very large mirrors there is a slight variation to be observed during a night's work, due to change of temperature; but this, I believe, is also the case with large refractors, and is not objectionable. I find, as Dr. Draper did, that a slow change of figure is liable to occur; this has happened once to a mirror quickly made and used, testing after some months giving quite different results, but it is, I believe, exceptional for such a thing to take place after more than a few days.

As far as the limit of size is concerned, the next mirror might very well be 8 feet in diameter; this would not be difficult to make on the lines given.

I cannot conclude this paper without referring to the assistance I have received during a part of the time from Mr. A. Taylor, and giving my thanks to Alfred James Wooldridge, who during nearly six years has been most careful and attentive in carrying out all the actual work of grinding, polishing, and figuring, under my direction, without a single blunder or mishap.

A LIST OF PERSONS

TO WHOM

THE MEDALS OR TESTIMONIALS OF THE SOCIETY

HAVE BEEN ADJUDGED.

1823.

June 13. CHARLES BABBAGE, Esq.

The Gold Medal.—For his Invention of an Engine for computing and printing Mathematical Tables.

Professor JOHANN FRIEDRICH ENCKE.

The Gold Medal.—For his Investigations relative to the Comet which bears his name.

CHARLES RUMKER, Esq.

The Silver Medal.—For his Rediscovery of ENCKE's Comet in 1822.

M. JEAN LOUIS PONS.

The Silver Medal.—For his Discovery of Two Comets in 1822.

1826.

Feb. 7. J. F. W. HERSCHEL, Esq., and JAMES SOUTH, Esq.

The Gold Medal, each.—For their important Researches on the subject of Multiple Stars.

Feb. 10. Professor STRUVE.

The Gold Medal.—For his important Researches on the subject of Multiple Stars.

1827.

Feb. 2. FRANCIS BAILY, Esq.

The Gold Medal.—For his "New Tables for determining the places of 2,881 Stars."

WILLIAM SAMUEL STRATFORD, Esq.

The Silver Medal.—For his Superintendence of the Computation of "New Tables for determining the places of 2,881 Stars."

Feb. 5. Colonel MARK BEAUFOY.

The Silver Medal.—For his valuable Collection of Observations, particularly those of the Eclipses of *Jupiter's* Satellites.

1828.
Jan. 11. Sir Thomas Macdougall Brisbane, K.C.B.
The Gold Medal.—For his Establishment of an Observatory, and for an important series of Observations made at Paramatta.

James Dunlop, Esq.
The Gold Medal.—For his Observations of the Nebulæ of the Southern Hemisphere.

Feb. 4. Miss Caroline Herschel.
The Gold Medal.—For her recent reduction, to January 1800, of the Nebulæ discovered by Sir William Herschel.

1829.
Jan. 9. Rev. William Pearson.
The Gold Medal.—For his work entitled "An Introduction to Practical Astronomy."

Professor Bessel.
The Gold Medal.—For his Zone Observations.

Professor Schumacher.
The Gold Medal.—For the publication of his various Astronomical Tables, and the "Astronomische Nachrichten."

1830.
Jan. 8. Mr. William Richardson.
The Gold Medal.—For his Investigation of the Constant of Aberration.

Professor Encke.
The Gold Medal.—For the New Berlin Ephemeris.

1831.
Jan. 14. Captain Kater.
The Gold Medal.—For his Invention of the Vertical Floating Collimator.

Baron Damoiseau.
The Gold Medal.—For his Memoir upon the Theory of the Moon, and for his Lunar Tables.

1833.
Jan. 11. Professor Airy.
The Gold Medal.—For his Discovery of the long Inequality of *Venus* and the Earth.

1835.
Jan. 9. Lieutenant Johnson.
The Gold Medal.—For his Catalogue of 606 Southern Stars.

1836.
Jan. 8. Sir John F. W. Herschel.
The Gold Medal.—For his Catalogue of Nebulæ, printed in the "Philosophical Transactions" for 1833.

1837.
Jan. 13. Professor Rosenberger.
The Gold Medal.—For his Investigations relative to Halley's Comet.

1839.
Jan. 11. Hon. John Wrottesley.
The Gold Medal.—For his Catalogue of the Right Ascensions of 1,318 Stars.

1840.
Jan. 10. M. Jean Plana.
The Gold Medal.—For his work, entitled "Théorie du Mouvement de la Lune."

1841.
Jan. 8. Professor Bessel.
The Gold Medal.—For his Observations and Researches on the Parallax of 61 *Cygni.*

1842.
Jan. 14. M. P. A. Hansen.
The Gold Medal.—For his Researches in Physical Astronomy.

1843.
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The Gold Medal.—For his Experiments to determine the Mean Density of the Earth in repetition of what is generally termed the "Cavendish Experiment."

1845.
Jan. 10. Captain William Henry Smyth, R.N.
The Gold Medal.—For his "Bedford Catalogue," forming the second part of his work entitled "Celestial Cycle."

1846.
Jan. 9. George Biddell Airy, Esq., Astronomer Royal.
The Gold Medal.—For his Reduction of the Observations of Planets made at the Royal Observatory, Greenwich, from 1750 to 1830.

1848. *Testimonials were awarded to*
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For the Lunar Reductions recently made at Greenwich.

John Couch Adams, Esq.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune.*

1848.
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For his work on the Southern Hemisphere.

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For his Lunar Theory and Computation of Perturbations.

M. HENCKE.
For his Discovery of two Planets, *Astræa* and *Hebe.*

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Sir JOHN LUBBOCK.
For his Researches in the Theory of Perturbations.

M. M. WEISSE.
For his Catalogue of Stars in BESSEL'S Zones.

1849.
Feb. 9. WILLIAM LASSELL, Esq.
The Gold Medal.—For the construction of his Equatorial Instrument and for the Discoveries made with it.

1850.
Feb. 8. M. OTTO VON STRUVE.
The Gold Medal.—For his Paper on the Constant of Precession.

1851.
Feb. 15. Dr. ANNIBALE DE GASPARIS.
The Gold Medal.—For the Discovery of three Planets, *Hygeia, Parthenope,* and *Egeria.*

1852.
Feb. 13. Dr. C. A. F. Peters.
The Gold Medal.—For his Papers on the Parallax of the Fixed Stars, and on the Constant of Nutation.

1853.
Feb. 11. John Russell Hind, Esq.
The Gold Medal.—For the Discovery of eight Planets, and other Astronomical Discoveries.

1854.
Feb. 10. M. Charles Rumker.
The Gold Medal.—For his Catalogue of 12,000 Stars, and for other Astronomical Services.

1855.
Feb. 9. Rev. W. R. Dawes.
The Gold Medal.—For his Astronomical Labours generally.

1856.
Feb. 8. Robert Grant, Esq., M.A.
The Gold Medal.—For his "History of Physical Astronomy."

1857.
Feb. 13. M. Schwabe.
The Gold Medal.—For his Discovery of the Periodicity of the Solar Spots.

1858.
Feb. 12. Rev. Robert Main, M.A.
The Gold Medal.—For his various Contributions to the *Memoirs* of the Society.

1859.
Feb. 11. R. C. Carrington, Esq.
The Gold Medal.—For his "Redhill Catalogue of 3,735 Circumpolar Stars."

1860.
Feb. 10. Professor P. A. Hansen.
The Gold Medal.—For his Lunar Tables.

1861.
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The Gold Medal.—For his Discovery of thirteen of the Minor Planets, and other Astronomical Discoveries.

1862.
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The Gold Medal.—For his Astronomical Researches, and especially for his Application of Photography.

1863.
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1865.
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The Gold Medal.—For his work on the Comet of DONATI, and other Astronomical Researches.

1866.
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1867.
Feb. 8. W. HUGGINS, Esq., and Professor MILLER.
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1868.
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The Gold Medal.—For his Planetary Tables.

1869.
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1870.
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1872.
Feb. 9. Signor G. V. SCHIAPARELLI.
The Gold Medal.—For his Researches on the Connexion between the Orbits of Comets and Meteors.

1874.
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The Gold Medal.—For his Tables of *Neptune* and *Uranus*, and other Contributions to Mathematical Astronomy.

1875.
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1879.
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1881.
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The Gold Medal.—For his Investigations of the Motion of FAYE'S Comet.

1882.
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The Gold Medal.—For his Heliometer observations of *Mars* at Ascension, and for his discussion of the results.

1883.
Feb. 9. Dr. B. A. GOULD.
The Gold Medal.—For his *Uranometria Argentina.*

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1885.
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1886.
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The Gold Medal.—For their Photometric Researches.

1887.
Feb. 11. G. W. HILL, Esq.
The Gold Medal.—For his Researches on the Lunar Theory.

1888.
Feb. 10. Professor ARTHUR AUWERS.
The Gold Medal.—For his Re-reduction of BRADLEY'S Observations.

1889.
Feb. 8. M. MAURICE LŒWY.
The Gold Medal.—For his Equatorial Coudé, his method of determining the Constant of Aberration, and his other Astronomical Researches.

1892.
Feb. 12. Professor G. H. DARWIN.
The Gold Medal.—For his work on the Tides and their Influence on the Figures and Motions of the Heavenly Bodies.

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CONTENTS.

PAGE

On the Investigation of the Division Errors of the Scales of the Cape Repsold Measuring Apparatus, and the Determination of the Errors of the Oxford Reseau. By DAVID GILL, LL.D., F.R.S., Her Majesty's Astronomer at the Cape of Good Hope 1

Spectrum of Nova Aurigæ. By the REV. W. SIDGREAVES, S.J. ... 29

Physical Observations of Mars, made at the Allegheny Observatory in 1892. By JAMES E. KEELER, D.Sc. 45

Comparison of the Greenwich Ten-Year Catalogue (1880) *with the Cape Catalogue* (1880). By H. H. TURNER, M.A., B.Sc., and H. P. HOLLIS, B.A. 53

An Experiment with a 12½*-inch Refractor, whereby the Light lost through the Secondary Spectrum is separated out and rendered approximately measurable.* By H. DENNIS TAYLOR 77

On the R—D Discordance. By H. H. TURNER, M.A., B.Sc., and W. G. THACKERAY 87

On the Rotation and Mechanical State of the Sun. By R. A. SAMPSON, M.A. 123

	PAGE
Index Catalogue of Nebulæ found in the years 1888 *to* 1894, *with Notes and Corrections to the New General Catalogue.* By J. L. E. DREYER, PH.D.	185
Double-Star Observations, 1892–94. By W. H. MAW	229
A Determination of the Constant of Nutation from Greenwich Meridian Observations of Polaris, 1836–1893. By W. G. THACKERAY ...	243
Further Measures of Double Stars made at the Temple Observatory, Rugby, during the Years 1890–1895. By G. M. SEABROKE and H. P. HIGHTON	267
List of Persons to whom Medals or Testimonials have been Adjudged	277

On the Investigation of the Division Errors of the Scales of the Cape Repsold Measuring Apparatus, and the Determination of the Errors of the Oxford Reseau. By DAVID GILL, LL.D., F.R.S., H.M. Astronomer at the Cape of Good Hope.

[Received and read January 8, 1892.]

THE investigation of the errors of the Oxford reseau has been undertaken at the request of Professor PRITCHARD.

The Reseau.

The reseau is represented in the accompanying figure (Plate I.). The standard lines are A_{14} and B_{14}, but these lines are not well defined near the extremities. For the length of the standard A line I have selected the points of its intersection by the lines B_2 and B_{26}, and for that of the standard B line the points of its intersection by the lines A_2 and A_{26}. Our standards thus become the points marked *a*, *b*, *c*, *d* in the diagram. The complete investigation of the reseau errors thus involves the following operations :—

1. The errors of the twenty-four subdivisions of each of the standard lines *ac* and *bd*.
2. Determination of the relative lengths of the lines *ac* and *bd*.
3. Measurement of the deviations of the ruled lines (which join the standard points *ac* and *bd*) from straight lines.
4. Determination of the angle of intersection of imaginary straight lines joining the points *ac* and *bd*.

5. Measures to determine whether each A line is parallel to *ac*, and each B line parallel to *bd*.
6. Construction of a table which shall combine the results of the above investigations so as to represent the absolute errors of each reseau intersection.

The usual method of determining division errors—viz. by successive bisection—is a very laborious one. It is also a very unsatisfactory process, because an error committed in any step of the operation is perpetuated in the results of all successive steps; the errors are, in fact, cumulative, and when many successive bisections have to be performed the error of some of the final results may be considerable.

To avoid these errors, and as a much more direct and satisfactory method, the errors of the twenty-four subdivisions of the fundamental lines *ac* and *bd* were determined by projecting upon the intersecting lines the corresponding lines of one of the scales of the Repsold measuring apparatus.

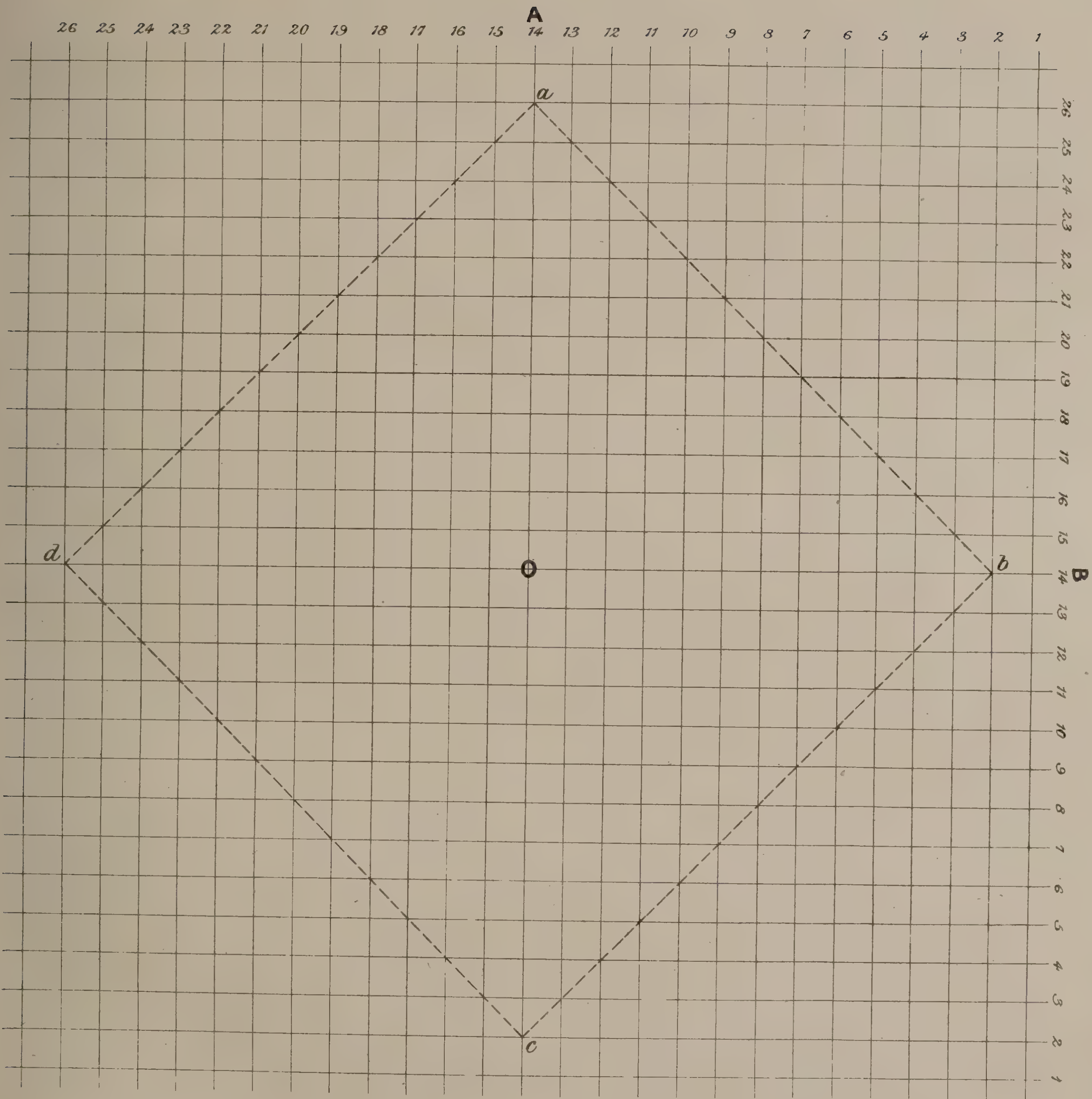
The Repsold Measuring Apparatus.

This apparatus resembles in most of its details the Leiden instrument, which is figured and described by Professor H. S. v. DE SANDE BAKHUYZEN (*Bulletin du Comité Permanent*, vol. i. p. 169); and a perusal of this description will sufficiently explain the manner in which the scale divisions can be projected upon and compared with the reseau lines. In the Cape as well as in the Leiden instrument the standard scale is divided to single millimetres. The subdivision of the millimetre is effected by a micrometer-microscope having a magnifying power of 60 diameters, and 10 revolutions of the screw correspond to 1 millimetre. The drumhead is divided into 100 parts, so that

$$1 \text{ part} = 0{\cdot}001^{\text{mm}} = 1 \textit{ micron}.$$

In comparing the intersections of the reseau lines with the scale care was taken to make the projections of the 5^{mm} divisions of the scale very nearly coincide with the reseau lines, so that the effect of error in the *run* of the micrometer had no influence on the results.

In consequence of the difference between the temperature coefficient of


A
B
a
b
c
d
O
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

the expansion of german silver (of which the scales are made) and that of the glass of the reseau, the reseau spaces under examination cannot be assumed to have a constant relation to the length of the corresponding spaces of the metallic scale. It is necessary, therefore, to conduct the comparisons symmetrically—that is to say, every observation must begin by comparisons of the reseau lines from A_2 to A_{26} with the corresponding divisions of the metallic scale, and then the process should be immediately repeated in the reverse order from A_{26} to A_2, so as to eliminate the effect of progressive change of temperature. In this way, provided that the division errors of the metallic scale are known, the division errors of the subdivisions of A_2 to A_{26} and of B_2 to B_{26} may be accurately determined, although the comparison of the absolute length of A and B may not be thus an accurate one, in consequence of the possible differences of temperature at which the comparatively prolonged series of observations have been made.

Two independent series of comparisons between the subdivisions of the reseau standard lines and the standard scale of the Repsold apparatus were made—one by Mr. Ray Woods, the other by Mr. Goodman. The results are given in the following table, I., which exhibits the excess of the micrometer readings on the reseau over the corresponding scale readings.

Increasing readings of the micrometer head correspond with diminishing readings of the scale; or, in other words, the readings of Table I. express the excess of the scale over the successive lengths of the reseau intersections. Each series rests on three independent determinations, each consisting of four pointings on the scale and reseau lines.

TABLE I.

*Excess of Scale over Reseau.**

Reseau.	Scale.	Woods.	Goodman.	W.−G.	Diff. Corrected for Common Diff. = v.	$(\frac{1}{2}v)^2$
		p	p	p	p	p
A 2	5	− 1·25	+ 0·44	−1·69	+·06	·0009
3	10	− 1·03	0·87	1·90	−·15	·0056
4	15	− 1·68	0·18	1·86	−·11	·0030
5	20	+ 2·17	4·19	2·02	−·27	·0182
6	25	+ 3·86	5·93	2·07	−·32	·0256
7	30	+ 6·14	7·67	1·53	+·22	·0121
8	35	+ 8·43	9·57	1·14	+·61	·0930
9	40	+ 9·32	11·42	2·10	−·35	·0306
10	45	+11·08	12·23	1·15	+·60	·0090
11	50	+12·05	13·66	1·61	+·14	·0049
12	55	+12·99	14·41	1·42	+·33	·0272
13	60	+15·00	16·58	1·58	+·17	·0072
14	65	+15·41	17·56	2·15	−·40	·0040
15	70	+18·43	19·97	1·54	+·21	·0110
16	75	+18·88	20·84	1·96	−·21	·0110
17	80	+21·60	23·21	1·61	+·14	·0049
18	85	+23·71	25·19	1·48	+·27	·0182
19	90	+24·12	26·34	2·22	−·47	·0552
20	95	+23·88	25·77	1·89	−·14	·0049
21	100	+26·12	27·73	1·61	+·14	·0049
22	105	+27·98	30·59	2·61	−·86	·1849
23	110	+29·35	30·27	·92	+·83	·1722
24	115	+29·98	31·47	1·49	−·26	·0169
25	120	+33·44	35·19	1·75	±·00	·0000
26	125	+33·02	+35·26	−2·24	−·49	·0600

* It appears from the results that the observations by Woods and Goodman must have been made nearly at the same temperature, because there is no progressive difference in the value of excess of scale over reseau in the two comparisons.

TABLE I.—*continued.*

Excess of Scale over Reseau.

Reseau.	Scale.	WOODS.	GOODMAN.	W.—G.	Progressive Correction.*	W.—G. Corrected.	v	$(\frac{1}{2}v)^2$
		p	p	p	p	p	p	p
B 2	5	+15·91	+18·12	−2·21	− ·043	−2·25	− ·40	·0400
3	10	16·19	19·24	3·05	·086	3·14	+ ·49	·0600
4	15	18·34	20·59	2·25	·129	2·38	− ·27	·0182
5	20	18·54	21·41	2·87	·172	3·04	+ ·39	·0380
6	25	22·06	24·14	2·08	·215	2·30	− ·35	·0306
7	30	21·28	23·61	2·33	·258	2·59	− ·06	·0009
8	35	24·01	26·91	2·90	·301	3·20	+ ·55	·0756
9	40	25·76	27·62	1·86	·344	2·20	− ·45	·0506
10	45	24·87	27·52	2·65	·387	3·04	+ ·39	·0380
11	50	27·54	30·27	2·73	·430	3·16	+ ·51	·0650
12	55	30·51	32·69	2·18	·473	2·65	·00	·0000
13	60	32·60	33·59	0·99	·516	1·51	−1·14	·3249
14	65	32·72	35·22	2·50	·559	3·06	+ ·41	·0420
15	70	36·44	38·50	2·06	·602	2·66	+ ·01	·0000
16	75	39·05	41·45	2·40	·645	3·05	+ ·40	·0400
17	80	40·22	41·88	1·66	·688	2·35	− ·30	·0225
18	85	40·94	42·69	1·75	·731	2·48	− ·17	·0072
19	90	42·18	43·82	1·64	·774	2·41	− ·24	·0144
20	95	42·24	44·11	1·87	·817	2·69	+ ·04	·0004
21	100	46·02	48·23	2·21	·860	3·07	+ ·42	·0441
22	105	48·28	50·38	2·10	·903	3·00	+ ·35	·0306
23	110	49·25	50·63	1·38	·946	2·33	− ·32	·0256
24	115	53·98	55·14	1·16	·989	2·15	− ·50	·0625
25	120	54·55	56·37	1·82	1·032	2·85	+ ·20	·0100
26	125	+53·99	+55·57	−1·58	−1·075	−2·66	+ ·01	·0000

* The comparisons by WOODS and GOODMAN have obviously been made at different temperatures; hence, on account of the different coefficients of expansion of the scale and reseau, there is a progressive difference of $+0^{p}·043$ in each 5^{mm} space. The correction for this difference is necessary to determine the accuracy of the comparison.

The investigation of the errors of the scale has been confined to determining the errors of each fifth division, as these errors alone enter into the present work.

The measuring instrument is provided with two scales. One (Scale A) is numbered from 0^{mm} to 130^{mm}, the other (Scale B) from 200^{mm} to 330^{mm}.

The scales are graduated on two polished bars of german silver, as nearly as possible identical in size, and are provided with ground edges so that the two sets of divisions can be brought into close juxtaposition, and one scale can be slid along the other, thus permitting either half of one scale to be compared with both halves of the other, and any division space on one half of one scale to be compared with all the divisions on the corresponding half of the other scale. It was thus possible to determine the division errors of both scales without cumulative error, precisely in the same manner as I determined the division errors of the Cape Heliometer Scales (*Monthly Notices of the Royal Astronomical Society*, vol. xlix. pp. 105–115).*

The first step is to determine the comparative lengths of the spaces 65—0 and 130—65 on Scale A, and 265—200 and 330—265 on Scale B.

Putting

α=the excess of the space 65— 0 over true half of Scale A.
β= " " 130— 65 " "
γ= " " 265—200 " "
δ= " " 300—265 " "

seven separate determinations gave

$\alpha-\gamma=$	$\beta-\gamma=$	$\alpha-\delta=$	$\beta-\delta=$
$\overset{p}{-1{\cdot}08}$	$\overset{p}{+0{\cdot}98}$	$\overset{p}{+0{\cdot}12}$	$\overset{p}{+2{\cdot}91}$
− ·67	− ·05	+ ·71	+2·75
− ·82	+1·28	+ ·15	+1·90
−2·32	+ ·90	− ·12	+2·47
−1·47	+ ·85	− ·18	+3·50
− ·78	+1·55	+ ·25	+2·45
− ·43	+1·38	+ ·62	+3·20
Mean −1·08	+0·98	+0·22	+2·74

* The reader who may peruse the paper in question is requested to correct a misprint on the second line of p. 112, viz. to read "because all the side equations are *rigidly* satisfied" instead of "*rapidly* satisfied."

The unit is 1 part = a division of the head = 1 micron = $0''.06$ (arc); whence

$$\alpha-\gamma=-1^p.08 \qquad \alpha-\delta=+0^p.22$$
$$\beta-\gamma=+0.98 \qquad \beta-\delta=+2.74$$
$$\therefore\ \alpha-\beta=-2.06 \qquad \alpha-\beta=-2.52 \qquad \text{Mean } \alpha-\beta=-2^p.29$$

If we adopt Scale A as standard (that is, adopt $\alpha+\beta=0^p.00$), and the above mean value $\alpha-\beta=-2^p.29$, we get

$$\alpha=-1^p.15 \qquad \gamma=+0^p.05$$
$$\beta=+1.15 \qquad \delta=-1.48$$

where

$$\left.\begin{aligned} \alpha &= \text{the division error of the line } (65) \\ \alpha+\beta &= \quad \text{,,} \qquad \text{,,} \qquad (130) \\ \gamma &= \quad \text{,,} \qquad \text{,,} \qquad (265) \\ \gamma+\delta &= \quad \text{,,} \qquad \text{,,} \qquad (330) \end{aligned}\right\} \quad . \quad . \quad . \quad (1)$$

The following table, II., gives the results of the comparisons of all the 5^{mm} subdivisions of the space (65—0), Scale A, with the corresponding subdivisions of the space (330—265), Scale B.

The mean result at the bottom of each vertical column is thus the excess of that space on Scale A (which is indicated at the top of each column) over the true thirteenth part of the space (330—265) on Scale B. The successive sums of these means would be the corresponding division errors if space (330—265) were equal to the true half of Scale A.

Similarly the means of the horizontal lines (given in the last right-hand column) represent the excess of the true thirteenth part of the space (65—0) over that portion of Scale B which is indicated in the left-hand column of the table. The successive sums of these excesses *with changed sign* would represent the corresponding division errors if the space (65—0) were equal to the true half of Scale A.

The results will be found in Table III.

The most convenient method of computing the final corrections due to the unequal lengths of the two scales and the errors of their middle points is to apply a proportional correction to each division such as shall reproduce from the successive sums of the lengths of the 5^{mm} spaces a correction

at the points 65, 130, 265, and 330 equal to the division errors already determined for these points in our equation (1).

TABLE II.

Excess of a over δ.

—	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	Mean Excess
325–330	− ·28	+ ·27	− ·03	+1·97	+ ·90	− ·59	+ ·27	+1·28	+ ·25	+ ·76	− ·58	+2·05	− ·53	+ ·44
320–325	− ·42	+1·20	− ·52	+1·65	+1·53	− ·25	+1·37	+ ·83	+ ·15	+1·53	+ ·69	+3·90	+ ·08	+ ·90
315–320	+ ·43	+ ·72	−1·15	+1·60	+1·86	+ ·07	+1·49	+1·02	+ ·93	+1·30	− ·40	+2·35	− ·47	+ ·75
310–315	+ ·40	+ ·10	−1·32	+1·07	+1·78	−1·11	+ ·40	+ ·28	− ·60	+ ·79	− ·98	+ ·27	−1·17	− ·01
305–310	−1·21	−1·90	−3·62	− ·65	− ·12	−3·56	−1·47	−1·48	−2·02	−2·57	−2·77	− ·07	−1·85	−1·79
300–305	− ·07	− ·70	−1·53	+1·79	+1·69	−1·25	+ ·43	+1·10	+ ·13	+ ·30	+ ·50	+ ·57	− ·30	+ ·20
295–300	− ·02	+1·00	−1·10	+ ·85	+ ·93	− ·37	+ ·80	+1·75	+ ·23	+ ·60	− ·21	+2·53	+ ·88	+ ·61
290–295	−1·30	− ·78	−2·51	+1·40	+1·38	− ·95	− ·77	− ·17	−2·47	− ·80	−1·52	+ ·73	−1·28	− ·70
285–290	+ ·57	+ ·27	−1·48	+ ·83	+ ·43	− ·43	+1·05	+ ·52	+ ·02	+1·19	− ·43	+1·97	− ·05	+ ·34
280–285	− ·35	− ·45	− ·67	+2·01	+1·42	+ ·17	+ ·65	+ ·13	−1·05	+ ·63	− ·27	+1·65	+ ·08	+ ·30
275–280	+ ·45	+ ·52	−1·25	+1·10	+1·39	+ ·28	+1·08	+ ·52	− ·13	+1·27	− ·10	+2·02	+ ·15	+ ·56
270–275	− ·65	−1·20	−2·92	+ ·42	+ ·50	−1·94	− ·80	− ·45	−1·22	−1·00	− ·27	+ ·37	−1·47	− ·82
265–270	+ ·73	− ·82	−1·53	+1·35	+1·83	− ·63	+ ·05	+1·33	− ·27	+ ·60	− ·65	+ ·48	− ·20	+ ·18
Mean Excess	− ·13	− ·14	−1·51	+1·18	+1·19	− ·81	+ ·35	+ ·51	− ·47	+ ·35	− ·54	+1·45	− ·47	

Excess of β over γ.

—	65–70	70–75	75–80	80–85	85–90	90–95	95–100	100–105	105–110	110–115	115–120	120–125	125–130	Mean Excess
260–265	+ ·15	+ ·59	− ·93	−1·32	− ·25	−1·52	− ·22	+ ·17	− ·80	+1·23	− ·10	−1·80	+ ·03	− ·37
255–260	−1·73	− ·55	−2·22	−1·27	− ·60	−1·95	−2·33	− ·51	−1·85	− ·31	−1·78	−2·58	−1·52	−1·48
250–255	+1·80	+3·33	+1·08	+ ·97	+1·49	+ ·12	+1·08	+2·45	+ ·08	+2·64	+1·59	+ ·25	+1·65	+1·43
245–250	+ ·45	+ ·27	+ ·07	− ·23	+1·11	− ·77	− ·57	+ ·54	− ·62	+2·37	− ·48	− ·37	+ ·33	+ ·16
240–245	+ ·57	+2·47	+ ·72	+ ·33	+ ·53	− ·73	+ ·45	+1·80	− ·32	+2·04	− ·57	− ·27	+ ·18	+ ·55
235–240	+ ·74	+1·62	− ·50	+ ·31	− ·80	− ·16	+ ·77	+ ·72	+ ·52	+2·65	+ ·88	− ·43	+ ·57	+ ·53
230–235	+ ·73	+1·25	−1·00	−1·22	− ·25	− ·52	− ·37	+ ·50	− ·32	+ ·51	+ ·02	−1·62	− ·55	− ·22
225–230	+ ·20	+1·84	+ ·30	+ ·46	+1·30	− ·23	+ ·97	+2·08	− ·40	+1·85	+ ·87	−1·52	+ ·12	+ ·60
220–225	+ ·35	+1·15	− ·97	− ·69	+ ·14	−1·37	+ ·02	− ·35	−1·80	+ ·73	− ·87	−1·90	− ·55	− ·47
215–220	− ·50	+ ·47	−1·02	−1·25	− ·08	−1·47	+ ·22	+ ·41	− ·75	+ ·77	− ·25	−1·48	− ·75	− ·44
210–215	−1·45	+ ·10	−2·57	−1·58	−1·08	−2·90	−1·88	−1·02	−2·21	+ ·07	−1·70	−2·95	−1·08	−1·56
205–210	+1·32	+1·97	+ ·07	+ ·97	+ ·88	+1·13	+1·00	+1·98	− ·40	+1·83	+ ·21	− ·42	+ ·92	+ ·88
200–205	+1·16	+1·92	+ ·13	+ ·36	+ ·93	− ·06	− ·30	+1·72	− ·22	+2·27	+1·32	+ ·20	+ ·60	+ ·77
Mean Excess	+ ·29	+1·26	− ·53	− ·32	+ ·26	− ·80	− ·09	+ ·81	− ·70	+1·43	− ·07	−1·15	·00	

The division errors of both scales may then be obtained as follows :

TABLE III.

Division.	Excess of Space from Table II.	Successive Sum of Excesses.	Proportional Correction to Reproduce the Error of (65) in Equation 1 *.	Definitive Division Error.
	p	p	p	p
0	...	...	−0·00	0·00
5	−0·13	−0·13	− ·16	− ·29
10	−0·14	− ·27	− ·32	− ·59
15	−1·51	−1·78	− ·48	−2·26
20	+1·18	− ·60	− ·64	−1·24
25	+1·19	+ ·59	− ·80	− ·21
30	−0·81	− ·22	− ·96	−1·18
35	+0·35	+ ·13	−1·13	−1·00
40	+0·51	+ ·64	−1·30	−0·66
45	−0·47	+ ·17	−1·47	−1·30
50	+0·35	+ ·52	−1·63	−1·11
55	−0·54	− ·02	−1·79	−1·81
60	+1·45	+1·43	−1·95	−0·52
65	−0·47	+ ·96	−2·11	−1·15
	From Table II.		To reproduce the errors of (65) and (130).	
65	...	...	−1·15	−1·15
70	+ ·29	+ ·29	−1·09	− ·80
75	+1·26	+1·55	−1·03	+ ·52
80	− ·53	+1·02	− ·98	+ ·04
85	− ·32	+ ·70	− ·92	− ·22
90	+ ·26	+ ·96	− ·86	+ ·10
95	− ·80	+ ·16	− ·80	− ·64
100	− ·09	+ ·07	− ·74	− ·67
105	+ ·81	+ ·88	− ·68	+ ·20
110	− ·70	+ ·18	− ·62	− ·44
115	+1·43	+1·61	− ·56	+1·05
120	− ·07	+1·54	− ·50	+1·04
125	−1·15	+ ·39	− ·45	− ·06
130	·00	+ ·39	− ·39	·00

NOTE.—The proportional correction applied in the fourth column of the above table, in order

Table III.—*continued.*

Division.	Excess of Space from Table II.	Successive Sum of Excesses.	Proportional Correction to Reproduce the Error of (265) in Equation 1.	Definitive Division Error.
	p	p	p	p
200	...	...	...	0·00
205	−0·77	−0·77	+0·03	− ·74
210	− ·88	−1·65	+ ·07	−1·58
215	+1·56	− ·09	+ ·10	+ ·01
220	+ ·44	+ ·33	+ ·14	+ ·47
225	+ ·47	+ ·80	+ ·17	+ ·97
230	− ·60	+ ·20	+ ·21	+ ·41
235	+ ·22	+ ·42	+ ·24	+ ·66
240	− ·53	− ·11	+ ·28	+ ·17
245	− ·55	− ·66	+ ·31	− ·35
250	− ·16	− ·82	+ ·35	− ·47
255	−1·43	−2·25	+ ·38	−1·87
260	+1·48	− ·77	+ ·42	− ·35
265	+ ·37	− ·40	+ ·45	+ ·05
	From Table II.		To reproduce the errors of (265) and (330).	
265	...	...	+0·05	+0·05
270	− ·18	− ·18	·00	− ·18
275	+ ·82	+ ·64	− ·04	+ ·60
280	− ·56	+ ·08	− ·09	− ·01
285	− ·30	− ·22	− ·13	− ·35
290	− ·34	− ·56	− ·18	− ·74
295	+ ·70	+ ·14	− ·22	− ·08
300	− ·61	− ·47	− ·27	− ·74
305	− ·20	− ·67	− ·31	− ·98
310	+1·79	+1·12	− ·35	+ ·77
315	+ ·01	+1·13	− ·39	+ ·74
320	− ·75	+ ·38	− ·43	− ·05
325	− ·90	− ·52	− ·47	− ·99
330	− ·44	− ·96	− ·52	−1·48

to reproduce the error of (65) equal to a in our equation (1), arises because the space (65–0) was compared with the space (330–265), which is not truly equal to $\frac{1}{2}$ scale A, but $= \frac{1}{2}$ scale $A + \delta$. This correction should therefore be $= \delta = -1^p{\cdot}48$, instead of $2^p{\cdot}11$ applied as above, a

When these definitive division errors are applied to the original observations the residual errors given in the following table, IV., are obtained. The mean of the squares of these errors is

$$\frac{[vv]}{n-1} = \epsilon^2 = {}^{p}{\cdot}2133.$$

Whence

the mean error of one comparison $= \epsilon = \pm\, 0^{p}{\cdot}46$.

And as the errors of the subdivision of the half-lengths of the scales are not cumulative (that is to say, the sum of the spaces is determined with the same accuracy as each individual space), the mean error of each division error is

$$\frac{\epsilon}{\sqrt{13}} = \pm 0^{p}{\cdot}13,$$

which, however, is increased considerably by the error of the determinations of α, β, γ, and δ.

TABLE IV.

Representation of the Observations of Table II., after substitution of the values of the Division Errors in Table III.

	65–70	70–75	75–80	80–85	85–90	90–95	95–100	100–105	105–110	110–115	115–120	120–125	125–130
	p	p	p	p	p	p	p	p	p	p	p	p	p
260–265	− ·20	+ ·33	+ ·05	+ ·66	+ ·17	+ ·38	− ·21	+ ·30	− ·24	− ·14	− ·31	+ ·30	− ·37
255–260	+ ·56	+ ·35	+ ·22	− ·51	− ·60	− ·31	+ ·78	− ·14	− ·31	+ ·28	+ ·25	− ·04	+ ·06
250–255	− ·05	− ·61	− ·16	+ ·17	+ ·23	+ ·54	+ ·29	− ·18	+ ·68	+ ·25	− ·20	+ ·05	− ·19
245–250	+ ·02	+ 1·17	− ·43	+ ·09	− ·67	+ ·15	+ ·66	+ ·45	+ ·10	− ·76	+ ·59	− ·61	− ·15
240–245	+ ·30	− ·63	− ·68	− ·07	+ ·31	+ ·51	+ ·04	− ·41	+ ·20	− ·03	+ 1·08	− ·31	+ ·40
235–240	+ ·10	+ ·19	+ ·51	− ·08	+ 1·61	− ·09	− ·31	+ ·64	− ·67	− ·67	− ·40	− ·18	− ·02
230–235	− ·63	− ·18	+ ·27	+ ·71	+ ·32	− ·47	+ ·09	+ ·12	− ·57	+ ·73	− ·28	+ ·27	+ ·36
225–230	+ ·71	+ ·04	− ·22	− ·16	− ·42	+ ·05	− ·44	− ·65	+ ·32	+ ·20	− ·32	+ ·98	+ ·50
220–225	− ·50	− ·33	− ·01	− ·07	− ·32	+ ·13	− ·55	+ ·72	+ ·66	+ ·26	+ ·36	+ ·30	+ ·11
215–220	+ ·39	+ ·39	+ ·0	+ ·53	− ·06	+ ·27	− ·71	± ·00	− ·35	+ ·26	− ·22	− ·08	+ ·35
210–215	+ ·21	− ·37	+ ·50	− ·27	− ·19	+ ·57	+ ·26	+ ·30	− ·02	− ·17	+ ·10	+ ·26	− ·45
205–210	− ·13	+ ·19	+ ·29	− ·39	+ ·28	− 1·03	− ·19	− ·27	+ ·60	+ ·50	+ ·62	+ ·16	− ·02
200–205	− ·07	+ ·14	+ ·13	+ ·12	+ ·13	+ ·06	+ 1·01	− ·11	+ ·32	− ·04	− ·59	− ·56	+ ·20

discordance equal to $0^{p}{\cdot}63$ (or $= 0''{\cdot}037$, when $1^{mm} = 60''$). This discordance arises from the combined errors of the successive sums of the observed lengths of the subdivisions of the scale and the errors of the entirely independent determinations of α and δ.

TABLE IV.—*continued.*

	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	60–65
	p	p	p	p	p	p	p	p	p	p	p	p	p
325–330	+ ·48	− ·08	−1·15	− ·46	+ ·62	+ ·11	+ ·40	− ·45	− ·40	− ·08	+ ·37	− ·27	+ ·39
320–325	+1·07	− ·56	− ·21	+ ·31	+ ·44	+ ·22	− ·25	+ ·45	+ ·15	− ·40	− ·45	−1·67	+ ·23
315–320	+ ·07	− ·23	+ ·27	+ ·21	− ·04	− ·25	− ·52	+ ·11	− ·78	− ·32	+ ·49	− ·27	+ ·63
310–315	− ·66	− ·37	− ·32	− ·02	− ·72	+ ·17	− ·19	+ ·09	− ·01	− ·57	+ ·31	+1·05	+ ·57
305–310	− ·83	− ·15	+ ·20	− ·08	− ·60	+ ·84	− ·10	+ ·07	− ·37	+1·01	+ ·32	− ·39	− ·53
300–305	+ ·02	+ ·64	+ ·10	− ·53	− ·42	+ ·52	− ·01	− ·52	− ·53	+ ·13	− ·96	+ ·96	− ·09
295–300	+ ·39	− ·64	+ ·09	+ ·83	+ ·76	+ ·06	+ ·04	− ·75	− ·21	+ ·25	+ ·17	− ·58	− ·85
290–295	+ ·35	− ·18	+ ·18	−1·04	−1·01	− ·68	+ ·29	− ·15	+1·17	+ ·33	+ ·16	− ·10	− ·01
285–290	− ·47	− ·18	+ ·20	+ ·58	+ ·99	− ·15	− ·48	+ ·21	− ·27	− ·61	+ ·12	+ ·29	− ·19
280–285	+ ·40	+ ·49	− ·66	− ·65	− ·05	− ·80	− ·13	+ ·55	+ ·75	− ·10	− ·09	− ·02	− ·37
275–280	− ·13	− ·21	+ ·19	+ ·53	+ ·25	− ·64	− ·29	+ ·43	+ ·10	− ·47	+ ·01	− ·12	− ·17
270–275	− ·42	+ ·12	+ ·47	− ·18	− ·25	+ ·19	+ ·20	+ ·01	− ·20	+ ·41	−1·21	+ ·14	+ ·06
265–270	− ·79	+ ·75	+ ·09	− ·10	− ·57	− ·11	+ ·36	− ·76	− ·14	− ·18	+ ·18	+1·04	− ·20

§ 2. *Comparison of the Lengths of ac and bd, and Deduction of their Definitive Division Errors.*

This comparison was made by setting the line *ac* parallel to the scale by means of the position circle of the measuring instrument, and adjusting the points *c* and *a* nearly to coincidence with the divisions 5 and 125 of the scale. The micrometer was read first on the scale division 5, then on the reseau at the point *c*; then the microscope was moved to the other end of the scale and read on the point *a* and on the scale division 125; a repetition of the observations in the inverse order completed the comparison. Then the line *bd* was made parallel to the scale, and the distance between the points *b* and *d* similarly compared with the distance between the divisions 5 and 125 of the scale; the scale readings were then repeated in inverse order. Finally, *ac* was again set parallel to the scale, and similar comparisons between the scale and reseau were repeated.

These operations constitute one complete symmetrical comparison, independent of the effects of the different temperature coefficients of the scale and reseau.

Three such comparisons by Mr. WOODS gave the following results for the excess of the line *ac* over *bd* :—

	p
	−3·00
	−3·00
	−3·26
Mean	−3·09

That is to say, if we accept the line joining the points bd as standard, the line ac is too short by $3^p{\cdot}09$ ($= 0''{\cdot}18$), and the division error of the point a is $-0{\cdot}00309^{mm}$. The definitive division errors are then obtained as follows :—

TABLE V.

Reseau.	From TABLE I. — Excess of Reseau over Scale. $\frac{W+G}{2}$.	From TABLE III. — Correction for Division Errors of Scale.	Corrected Excess of Reseau.	Progressive Correction.	Definitive Division Error of Reseau.
	p	p	p	p	p
A 2	+ 0·41	−0·29	+ 0·12	− 0·12	±0·00
3	+ ·08	− ·59	− ·51	+ 1·31	+ ·80
4	+ ·75	−2·26	1·51	2·74	+1·23
5	− 3·18	−1·24	4·42	4·17	− ·25
6	4·90	−0·21	5·11	5·60	+ ·49
7	6·91	−1·18	8·09	7·03	−1·06
8	9·00	−1·00	10·00	8·46	−1·54
9	10·37	− ·66	11·03	9·89	−1·14
10	11·66	−1·30	12·96	11·32	−1·64
11	12·86	−1·11	13·97	12·75	−1·22
12	13·70	−1·81	15·51	14·18	−1·33
13	15·79	− ·52	16·31	15·61	− ·70
14	16·49	−1·15	17·64	17·04	− ·60
15	19·20	− ·80	20·00	18·47	−1·53
16	19·86	+ ·52	19·34	19·90	+ ·56
17	22·41	+ ·04	22·37	21·33	−1·04
18	24·45	− ·22	24·67	22·76	−1·91
19	25·23	+ ·10	25·13	24·19	− ·94
20	24·83	− ·64	25·47	25·62	+ ·15
21	26·93	− ·67	27·60	27·05	− ·55
22	29·29	+ ·20	29·09	28·48	− ·61
23	29·81	− ·44	30·25	29·91	− ·34
24	30·73	+1·05	29·68	31·34	+1·66
25	34·32	+1·04	33·28	32·77	− ·51
26	−34·14	− ·05	−34·20	+34·20	±0·00

TABLE V.—*continued.*

Reseau.	From Table I. — Excess of Reseau over Scale. $\frac{W+G}{2}$.	From Table III. — Correction for Division Errors of Scale.	Corrected Excess of Reseau.	Proportional Correction to give True Length of Scale B.	Definitive Division Error of Reseau.
	p	p	p	p	p
B 2	−17·02	−0·29	−17·31	+17·310	±0·00
3	17·72	− ·59	18·31	18·745	+ ·44
4	19·47	−2·26	21·73	20·180	−1·55
5	19·98	−1·24	21·22	21·615	+ ·40
6	23·10	− ·21	23·31	23·050	− ·26
7	22·45	−1·18	23·63	24·485	+ ·86
8	25·46	−1·00	26·46	25·920	− ·54
9	26·69	− ·66	27·35	27·355	+ ·01
10	26·20	−1·30	27·50	28·790	+1·29
11	28·91	−1·11	30·02	30·225	+ ·21
12	31·60	−1·81	33·41	31·660	−1·75
13	33·10	−0·52	33·62	33·095	− ·52
14	33·97	−1·15	35·12	34·530	− ·59
15	37·47	− ·80	38·27	35·965	−2·30
16	40·25	+ ·52	39·73	37·400	−2·33
17	41·05	+ ·04	41·01	38·835	−2·17
18	41·82	− ·22	42·04	40·270	−1·77
19	43·00	+ ·10	42·90	41·705	−1·19
20	43·18	− ·64	43·82	43·140	− ·68
21	47·13	− ·67	47·80	44·575	−3·22
22	49·33	+ ·20	49·13	46·010	−3·12
23	49·94	− ·44	50·38	47·445	−2·93
24	54·56	+1·05	53·51	48·880	−4·63
25	55·46	+1·04	54·42	50·315	−4·11
26	−54·78	− ·06	−54·84	+51·749	−3·09

§ 3. *Investigation of the Deviations of the Lines A_{14} and B_{14} from Straight Lines joining the Standard Points ac and bd respectively.*

Several methods were considered for this purpose. The following appears to be the most direct and accurate—viz. to measure, in a direction at right angles to the reseau line, the distance between the reseau line and the projection (on the plane of the reseau) of a tightly stretched spider line at a little height above the plane of the reseau, and nearly parallel to the reseau line under investigation.

This method is well adapted for use with the Repsold measuring apparatus, because the spider line may be mounted on the reseau itself, at some height above the plane of the reseau, and the position of its projection on the reseau be measured in a manner precisely similar with that in which the readings of the scale are projected on the photographic plate in Bakhuyzen's method of measuring.

But I feared the possible chance of injuring the silvered surface in making attachments to the reseau for mounting a spider web, and I adopted the following plan, which, though not quite so direct, is still capable of great accuracy.

In Bakhuyzen's account of the instrument it will be seen that whilst for measures of distance along any particular line the micrometer microscope is moved from point to point along that line, in order to project the corresponding reading of scale A upon the reseau, the plate itself is moved at right angles to this line, in order to permit the measurement of position angles. For the latter purpose it is necessary that this movement should be very accurate; in other words, that a point on the reseau should in this motion describe a perfectly straight line. This is a condition which it is mechanically very difficult to fulfil.

An ordinary dovetail slide is quite inadequate for such a purpose; either it fits too tightly for free motion, or if it moves with sufficient freedom it must of necessity have shake, and thus errors in its motion are inevitable.

Messrs. Repsold have adopted the plan which seems most likely to give an accurate result—viz. the slide which carries the reseau and the position circle rests on five points. Two pairs of these contact points are the surfaces

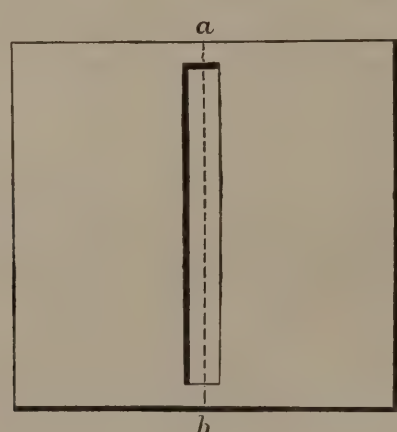
of Λ-shaped bearings which rest on a cylinder whose axis is in the direction of motion; the fifth point rests on a plane parallel to the axis of the cylinder. This arrangement has the following advantages:

1st. There is no possibility of looseness or shake, because the slide has only the five necessary limitations of freedom, and absolute contact at the limiting points is automatically secured apart from any consideration of perfect or imperfect workmanship.

2nd. The mechanical facilities for turning, grinding, and testing a cylinder are probably greater than for any other method of perfecting a slide motion.

The first of these conditions is, however, alone important in the present instance—viz. absolute freedom from shake; in other words, the perfection of the power to reproduce the same errors in the motion. It is then easy to investigate the error of the slide. This investigation was carried out between the investigation of the errors of the A and B lines in the following manner:

A brass plate was made precisely similar in thickness and other dimensions to the glass plate of the reseau, except that a slot of about 1^{cm} in breadth and 130^{cm} in length was filed out in the centre of the plate, as in the figure. Fine



lines were ruled at a and b (as in the web frame of a micrometer), and a spider-web ab (which had been previously suspended for some hours in water with

a lead weight at one end) was laid in the grooves *ab*, tightly stretched and fixed by varnish. This brass plate with its spider-web was then fixed in the measuring instrument in place of the reseau, and the spider-web, by means of the slow motion of the position circle, was made as nearly as possible parallel to the axis of the cylinder. This having been done, if the spider-web is bisected at any point of its length by the microscope it should remain bisected at any other point, when the slide which carries the brass plate is moved in the direction of the axis of the cylinder. This can only be rigorously true—

1st, If the axis of the spider-web is a straight line.
2nd, If this axis is parallel to the axis of the cylinder.
3rd, If the cylinder is perfectly true.

The rigorous fulfilment of the first of these conditions can hardly be questioned. The web was perfectly true and uniform in diameter throughout, and was so tightly stretched that breathing on it for a long time did not produce any sagging ; when under the microscope it could be displaced by side pressure with a needle at its middle point as far as the border of the field, and on removal of the pressure the web would immediately spring back to the normal position.

To detect the combined effects of non-parallelism of the web with the cylinder axis and errors in the cylinder itself, it is only necessary to bisect the web at uniform intervals, these intervals being defined by the scale B, which is attached to the slide. If the micrometer readings increase or diminish proportionally with the readings of scale B, any changes in these readings are due to non-parallelism of the web with the cylinder axis. If after such correction outstanding errors remain, they are due to errors in the cylinder.

The results of measures of this kind made by Messrs. Woods and Goodman are given in Table VI.

The first column for each observer gives the reading of scale B, which defines the part of the web at which the microscope was read.

The second column gives the mean of the actual micrometer readings at the different points in the length of the web.

The third gives the proportional corrections necessary to make the micrometer readings equal to zero at the scale readings 325 and 205.

The fourth column gives the result of the addition of the second and third columns, and is the combined error of the cylinder and the errors of observation.

The two right-hand columns give the mean of the results so obtained by the two observers, and the figures resulting from smoothing out the errors of observation by means of a curve, respectively.

The values derived from this curve are adopted as definitive.

TABLE VI.

Observations to Determine the Errors of Position Angle Cylinder.

Scale B.	Woods.			Goodman.			Mean.	Curve.
	Micrometer Readings.	Proportional Correction.	Errors of the Cylinder.	Micrometer Readings.	Proportional Correction.	Errors of the Cylinder.		
	p	p	p	p	p	p	p	p
325	16·01	−16·01	±0·00	15·43	−15·43	±0·00	±0·00	−0·00
320	15·62	15·99	− ·37	14·57	15·39	− ·82	− ·60	·50
315	16·08	15·97	+ ·11	14·50	15·35	·85	·37	·98
310	14·40	15·95	−1·55	13·70	15·31	1·61	1·58	1·42
305	14·18	15·93	1·75	13·78	15·27	1·49	1·62	1·81
300	13·55	15·91	2·36	13·15	15·23	2·08	2·22	2·20
295	12·93	15·89	2·96	12·33	15·19	2·86	2·91	2·56
290	13·42	15·87	2·45	12·73	15·15	2·42	2·44	2·87
285	12·45	15·85	3·40	11·68	15·11	3·43	3·42	3·15
280	12·48	15·83	3·35	11·77	15·07	3·30	3·33	3·40
275	12·53	15·81	3·28	12·12	15·03	2·91	3·10	3·62
270	11·63	15·79	4·16	11·07	14·99	3·92	4·04	3·75
265	11·67	15·77	4·10	10·87	14·95	4·08	4·09	3·85
260	12·02	15·75	3·73	11·13	14·91	3·78	3·76	3·86
255	11·33	15·73	4·40	10·97	14·87	3·90	4·15	3·82
250	12·62	15·71	3·09	11·52	14·83	3·31	3·20	3·71
245	12·05	15·69	3·64	11·07	14·79	3·72	3·68	3·55
240	12·53	15·67	3·14	11·83	14·75	2·92	3·03	3·35
235	11·55	15·65	4·10	11·12	14·71	3·59	3·85	3·11
230	12·80	15·63	2·83	12·35	14·67	2·32	2·58	2·85
225	12·68	15·61	2·93	12·07	14·63	2·56	2·75	2·50
220	13·80	15·59	1·79	13·00	14·60	1·60	1·70	2·11
215	13·33	15·56	2·23	12·65	14·57	1·92	2·08	1·60
210	14·17	15·53	−1·36	13·57	14·54	− ·97	−1·17	− ·98
205	15·51	−15·51	±0·00	14·51	14·51	±0·00	±0·00	±0·00

In Table VII. are given the corresponding results, when, instead of the spider-web, the lines A_{14} and B_{14} were bisected at different points of their length ; the definitively adopted values being those of the curve in the extreme right-hand column.

TABLE VII.

Observations to Determine the Combined Errors of the Cylinder and Reseau Line A_{14}.

Reseau.	Scale B.	Woods.			Goodman.			Mean.	Curve.
		Micrometer Readings.	Proportional Correction.	Combined Errors of Cylinder and Reseau Line.	Micrometer Readings.	Proportional Correction.	Combined Errors of Cylinder and Reseau Line.		
		p	p	p	p	p	p	p	p
B 2	325	90·81	−90·81	±0·00	90·91	−90·91	±0·00	±0·00	±0·00
3	320	90·55	90·85	− ·30	91·23	90·99	+ ·24	·03	− ·60
4	315	90·65	90·90	·25	90·10	91·07	− ·97	·61	1·17
5	310	88·33	90·94	2·61	89·40	91·15	1·75	2·18	1·67
6	305	88·50	90·99	2·49	89·13	91·23	2·10	2·30	2·12
7	300	88·60	91·03	2·43	89·10	91·31	2·21	2·32	2·51
8	295	88·03	91·08	3·05	88·40	91·40	3·00	3·03	2·85
9	290	87·70	91·12	3·42	88·20	91·48	3·28	3·35	3·13
10	285	88·00	91·17	3·17	88·50	91·56	3·06	3·12	3·34
11	280	87·80	91·21	3·41	88·15	91·64	3·49	3·45	3·52
12	275	87·40	91·25	3·85	88·08	91·72	3·64	3·75	3·63
13	270	87·90	91·29	3·39	88·25	91·81	3·56	3·48	3·70
14	265	87·23	91·34	4·11	88·01	91·89	3·88	4·00	3·71
15	260	87·13	91·38	4·25	88·35	91·97	3·62	3·94	3·70
16	255	87·90	91·43	3·53	88·85	92·05	3·20	3·37	3·65
17	250	87·80	91·47	3·67	88·65	92·13	3·48	3·58	3·57
18	245	87·85	91·52	3·67	89·10	92·22	3·12	3·40	3·38
19	240	88·30	91·56	3·26	89·50	92·30	2·80	3·03	3·17
20	235	89·03	91·61	2·58	89·78	92·38	2·60	2·59	2·90
21	230	88·83	91·65	2·82	89·60	92·46	2·86	2·84	2·60
22	225	89·68	91·70	2·02	90·23	92·54	2·31	2·17	2·24
23	220	90·38	91·74	1·36	91·00	92·63	1·63	1·50	1·80
24	215	90·68	91·79	1·11	90·90	92·71	1·81	1·46	1·27
25	210	91·45	91·83	−1·38	91·98	92·79	− ·81	− 1·10	− ·70
26	205	91·88	−91·88	±0·00	92·88	−92·88	±0·00	±0·00	±0·00

Table VII.—*continued.*

Observations to Determine the Combined Errors of the Cylinder and Reseau Line B_{14}.

Reseau.	Scale B.	Woods. Micrometer Readings.	Woods. Proportional Correction.	Woods. Combined Errors of Cylinder and Reseau Line.	Goodman. Micrometer Readings.	Goodman. Proportional Correction.	Goodman. Combined Errors of Cylinder and Reseau Line.	Mean.	Curve.
		p	p	p	p	p	p	p	p
A 2	205	98·05	−98·05	±0·00	99·50	−99·50	±0·00	±0·00	±0·00
3	210	97·20	97·94	− ·74	98·10	99·38	−1·28	−1·01	− ·92
4	215	96·20	97·83	1·63	97·60	99·25	1·65	1·64	1·74
5	220	95·30	97·73	2·43	96·68	99·12	2·44	2·44	2·41
6	225	94·88	97·62	2·74	96·18	99·00	2·82	2·78	2·98
7	230	94·00	97·51	3·51	95·20	98·88	3·68	3·60	3·47
8	235	93·40	97·40	4·00	94·38	98·75	4·37	4·19	3·80
9	240	93·38	97·30	3·92	94·55	98·63	4·08	4·00	4·07
10	245	92·83	97·19	4·36	94·58	98·51	3·93	4·15	4·30
11	250	92·78	97·08	4·30	94·15	98·39	4·24	4·27	4·42
12	255	92·40	96·97	4·57	93·85	98·27	4·42	4·50	4·55
13	260	92·00	96·86	4·86	93·75	98·15	4·40	4·63	4·60
14	265	92·13	96·75	4·62	93·83	98·02	4·19	4·41	4·60
15	270	92·23	96·65	4·42	92·98	97·90	4·92	4·67	4·58
16	275	91·60	96·54	4·94	93·45	97·78	4·33	4·64	4·50
17	280	91·60	96·43	4·83	93·63	97·66	4·03	4·43	4·36
18	285	92·10	96·32	4·22	93·18	97·54	4·36	4·29	4·15
19	290	92·13	96·21	4·08	93·83	97·42	3·59	3·84	3·90
20	295	92·45	96·10	3·65	93·93	97·29	3·36	3·51	3·55
21	300	92·78	96·00	3·22	94·30	97·17	2·87	3·05	3·12
22	305	92·90	95·89	2·99	94·65	97·05	2·40	2·70	2·66
23	310	93·40	95·78	2·38	94·83	96·93	2·10	2·24	2·10
24	315	93·95	95·67	1·72	95·18	96·81	1·63	1·68	1·58
25	320	94·73	95·56	− ·83	96·05	96·69	− ·64	− ·74	− ·89
26	325	95·45	−95·45	±0·00	96·57	−96·57	±0·00	±0·00	±0·00

For the measures given in Tables VI. and VII. the reseau was fixed in the measuring apparatus so that increasing readings of the micrometer corresponded with diminishing readings of the reseau. Therefore the signs of the definitive results in the right-hand column of Table VI. require to be reversed in order to express the *errors* of the lines in the direction of increasing numbers on the reseau, and the *corrections* for the errors of the cylinder will have the same signs as given in Table V.

We thus obtain the definitive errors of the lines as follows :—

TABLE VIII.

From TABLE VII. Combined Errors of A_{14} and Cylinder.			Corrections for Errors of Cylinder. TABLE VI.	Resulting Errors of A_{14}	Combined Errors of B_{14} and Cylinder. From TABLE VII.			Correction for Errors of Cylinder. TABLE VI.	Resulting Error of B_{14}.
Line. B 2 or	Scale. 325	p 0·00	p ± 0·00	p ± 0·00	Reseau A 2 or	Scale. 205	p ± 0·00	p ± 0·00	p ± ·00
3	320	+ ·60	−0·50	+ ·10	3	210	+ ·92	− ·98	− ·06
4	315	+1·17	−0·98	+ ·09	4	215	+1·74	−1·60	+ ·14
5	310	+1·67	−1·42	+ ·25	5	220	+2·41	−2·11	+ ·30
6	305	+2·12	−1·81	+ ·31	6	225	+2·98	−2·50	+ ·48
7	300	+2·51	−2·20	+ ·31	7	230	+3·47	−2·85	+ ·62
8	295	+2·85	−2·56	+ ·29	8	235	+3·80	−3·11	+ ·69
9	290	+3·13	−2·87	+ ·26	9	240	+4·07	−3·35	+ ·72
10	285	+3·34	−3·15	+ ·19	10	245	+4·30	−3·55	+ ·75
11	280	+3·52	−3·40	+ ·12	11	250	+4·42	−3·71	+ ·71
12	275	+3·63	−3·62	+ ·01	12	255	+4·55	−3·82	+ ·73
13	270	+3·70	−3·75	− ·05	13	260	+4·60	−3·86	+ ·74
14	265	+3·71	−3·85	− ·14	14	265	+4·60	−3·85	+ ·75
15	260	+3·70	−3·86	− ·16	15	270	+4·58	−3·75	+ ·83
16	255	+3·65	−3·82	− ·17	16	275	+4·50	−3·62	+ ·88
17	250	+3·57	−3·71	− ·14	17	280	+4·36	−3·40	+ ·96
18	245	+3·38	−3·55	− ·17	18	285	+4·15	−3·15	+1·00
19	240	+3·17	−3·35	− ·18	19	290	+3·90	−2·87	+1·03
20	235	+2·90	−3·11	− ·21	20	295	+3·55	−2·56	+ ·99
21	230	+2·60	−2·85	− ·25	21	300	+3·12	−2·20	+ ·92
22	225	+2·24	−2·50	− ·26	22	305	+2·66	−1·81	+ ·85
23	220	+1·80	−2·11	− ·31	23	310	+2·10	−1·42	+ ·68
24	215	+1·27	−1·60	− ·33	24	315	+1·58	−0·98	+ ·60
25	210	+0·70	−0·98	− ·28	25	320	+0·89	−0·50	+ ·39
26	205	± 0·00	± 0·00	± 0·00	26	325	± ·00	± 0·00	± 0·00

§ 4. *Determination of the Angle of Intersection of Imaginary Straight Lines Joining the Points ac and bd.*

The most accurate method for this purpose appears to be to measure the four sides of the quadrilateral a, b, c, d.

These measures were made in a similar manner with that described in § 2, viz :—by comparing the four sides successively and in symmetrical order with the same divisions of the scale.

The results obtained were the following:

Excess of Lengths of Sides of Quadrilateral over the Scale Interval.

Observer. Woods.	Mean.	Observer. Goodman.	Mean.
mm.	mm.	mm.	mm.
cd −·1690, −·1684	−·1687	−·1706, −·1671	−·1689
bc −·1793, −·1776	−·1785	−·1812, −·1786	−·1799
ab −·1697, −·1708	−·1703	−·1700, −·1704	−·1702
ad −·1782, −·1774	−·1778	−·1796, −·1778	−·1787
Mean excess ...	−·1738		−·1744

The relative excesses of the lengths of the sides over the mean are therefore—

	Observer. Woods.	Observer. Goodman.	Mean.
	mm.	mm.	mm.
cd	+·0051	+·0055	+·0053
cb	−·0047	−·0055	−·0051
ab	+·0035	+·0042	+·0039
ad	−·0040	−·0043	−·0041

If we denote the angle aOb by

$$90^\circ+\phi$$

we have

$$\tan\phi=\frac{\frac{1}{4}(ab+cd-ad-bc)\sin 45^\circ}{aO}$$

$$=\frac{\cdot0046^{\mathrm{mm}}\sin 45^\circ}{60}$$

and

$$\phi=+11''\cdot17.$$

The effect of this error on the A co-ordinates will be most conveniently computed thus :

$$\text{Error of } A_m = 5 \tan 11''\cdot17\ (N-14)$$
$$= 0\cdot000271^{mm}\ (N-14)$$
$$= 0^{p}\cdot271\ (N-14)$$

where A_m is the A line whose number is m, and whose error (in the direction A_1 to A_{26}) is required at the point of its intersection by a B line whose number is N.

TABLE IX.

Errors of the A Co-ordinates on account of the Error ϕ in the Angle of Intersection of the Reseau Lines.

Argument.	Error.	Argument.	Error.	Argument.	Error.
	p		p		p
B 1	−3·52	B 10	−1·08	B 19	+1·36
2	−3·25	11	−0·81	20	+1·63
3	−2·98	12	−0·54	21	+1·90
4	−2·71	13	−0·27	22	+2·17
5	−2·44	14	0·00	23	+2·44
6	−2·17	15	+0·27	24	+2·71
7	−1·90	16	+0·54	25	+2·98
8	−1·63	17	+0·81	26	+3·25
9	−1·36	18	+1·08	27	+3·52

In the parallelism of the lines I have found no sensible errors. The extreme lines have been very carefully measured, and found to be absolutely parallel within the very narrow limits of errors of observation.

The other lines have been carefully measured at various points, with a similar result.

The following tables give the sums of all the other errors expressed in ten-thousandths of a millimetre—*i.e.* the unit is $= 0^{mm}\cdot0001$, and I do not think any one of the corrections is in error by more than five of these units—that is (if $1^{mm} = 1'$ of arc), the error of the determination in no case exceeds $0''\cdot03$.

The errors contained in the table are to be added to the nominal linear equivalents of the co-ordinates in order to convert the nominal into true rectangular linear co-ordinates.

Errors of the

	A 1	2	3	4	5	6	7	8	9	10	11	12	13
At B_1	...	...	...	...	...	...	...	...	...	...	...	...	...
B_2	...	−33	−25	−20	−30	−28	−43	−48	−44	−49	−45	−46	−40
B_3	...	−29	−21	−17	−26	−24	−39	−44	−40	−45	−41	−42	−36
B_4	...	−26	−18	−14	−29	−21	−37	−42	−38	−43	−38	−40	−33
B_5	...	−22	−14	−10	−24	−17	−33	−37	−33	−38	−34	−35	−29
B_6	...	−19	−11	−06	−21	−14	−29	−34	−30	−35	−31	−32	−26
B_7	...	−16	−08	−04	−18	−11	−27	−31	−27	−32	−28	−29	−23
B_8	...	−13	−05	−01	−16	−09	−24	−29	−25	−30	−26	−27	−21
B_9	...	−10	−02	+02	−13	−05	−21	−25	−21	−26	−22	−23	−17
B_{10}	...	−09	−01	+03	−11	−04	−20	−24	−20	−25	−21	−22	−16
B_{11}	...	−07	+01	+05	−09	−02	−18	−22	−18	−23	−19	−20	−14
B_{12}	...	−05	+03	+07	−08	00	−16	−21	−17	−22	−18	−19	−12
B_{13}	...	−03	+05	+09	−06	+02	−14	−19	−15	−20	−15	−17	−10
B_{14}	...	−01	+07	+11	−04	+04	−12	−17	−13	−18	−14	−15	−09
B_{15}	...	+01	+09	+13	−01	+06	−10	−14	−10	−15	−11	−12	−06
B_{16}	...	+04	+12	+16	+01	+09	−07	−12	−08	−13	−09	−10	−03
B_{17}	...	+07	+15	+19	+04	+12	−04	−09	−05	−10	−06	−07	00
B_{18}	...	+09	+17	+21	+07	+14	−02	−06	−02	−07	−03	−04	+02
B_{19}	...	+12	+20	+24	+09	+17	+01	−04	−00	−05	−00	−02	+05
B_{20}	...	+14	+22	+27	+12	+19	+04	−01	+03	−02	+02	+01	+07
B_{21}	...	+17	+25	+29	+14	+21	+06	+01	+05	00	+04	+03	+09
B_{22}	...	+19	+27	+31	+17	+24	+09	+04	+08	+03	+07	+06	+12
B_{23}	...	+21	+29	+34	+19	+26	+11	+06	+10	+05	+09	+08	+14
B_{24}	...	+24	+32	+36	+21	+29	+13	+08	+12	+07	+12	+11	+17
B_{25}	...	+27	+35	+39	+25	+32	+16	+12	+16	+11	+15	+14	+20
B_{26}	..	+33	+41	+45	+30	+37	+22	+17	+21	+16	+20	+19	+25

Co-ordinates in A.

14	15	16	17	18	19	20	21	22	23	24	25	26	
...	...	...	...	...	...	...	...	...	...	...	...	...	B_1
−39	−48	−27	−43	−52	−42	−31	−38	−38	−36	−16	−38	−33	B_2
−35	−44	−23	−39	−48	−38	−27	−34	−35	−32	−12	−34	−29	B_3
−32	−41	−20	−36	−45	−35	−25	−32	−32	−30	−10	−31	−26	B_4
−28	−37	−16	−32	−41	−31	−20	−27	−28	−25	−05	−27	−22	B_5
−25	−34	−13	−29	−38	−28	−17	−24	−25	−22	−02	−24	−19	B_6
−22	−31	−10	−26	−35	−25	−14	−21	−22	−19	+01	−21	−16	B_7
−19	−29	−07	−23	−33	−23	−12	−19	−19	−17	+03	−19	−13	B_8
−16	−25	−04	−20	−29	−19	−08	−15	−16	−13	+07	−15	−10	B_9
−15	−24	−03	−19	−28	−18	−07	−14	−15	−12	+08	−14	−09	B_{10}
−13	−02	−01	−17	−26	−16	−05	−12	−13	−10	+10	−12	−07	B_{11}
−11	−21	+01	−15	−24	−14	−04	−11	−11	−09	+11	−10	−05	B_{12}
−09	−18	+03	−13	−22	−12	−02	−09	−09	−07	+13	−08	−03	B_{13}
−07	−17	+05	−11	−21	−11	−00	−07	−07	−05	+15	−07	−01	B_{14}
−05	−14	+07	−09	−18	−08	+03	−04	−05	−02	+18	−04	+01	B_{15}
−02	−12	+10	−06	−15	−05	+05	−02	−02	00	+20	−01	+04	B_{16}
+01	−09	+13	−03	−12	−02	+08	+01	+01	+03	+23	+02	+07	B_{17}
+03	−06	+15	−01	−10	00	+11	+04	+03	+06	+26	+04	+09	B_{18}
+06	−03	+18	+02	−07	+03	+14	+07	+06	+09	+28	+07	+12	B_{19}
+08	−01	+20	+04	−05	+05	+16	+09	+08	+11	+31	+09	+14	B_{20}
+11	+01	+23	+07	−03	+07	+18	+11	+11	+13	+33	+11	+17	B_{21}
+13	+03	+25	+09	00	+10	+21	+14	+13	+16	+36	+14	+19	B_{22}
+15	+06	+27	+11	+02	+12	+23	+16	+15	+18	+38	+16	+21	B_{23}
+18	+09	+30	+14	+05	+15	+26	+19	+18	+21	+40	+19	+24	B_{24}
+21	+12	+33	+17	+08	+18	+29	+22	+21	+24	+44	+22	+27	B_{25}
+27	+17	+39	+23	+13	+23	+34	+27	+27	+29	+49	+27	+33	B_{26}

Errors of the

	B 1	2	3	4	5	6	7	8	9	10	11	12	13
At A_1	...	...	...	...	...	...	...	...	...	...	...	...	...
A_2	...	00	+04	−16	+04	−03	+09	−05	00	+13	+02	−18	−05
A_3	...	−01	+04	−16	+03	−03	+08	−06	−01	+12	+02	−18	−06
A_4	...	+01	+06	−14	+05	−01	+10	−04	+02	+14	+04	−16	−04
A_5	...	+03	+07	−13	+07	00	+12	−02	+03	+16	+05	−15	−02
A_6	...	+05	+09	−11	+09	+02	+13	−01	+05	+18	+07	−13	−01
A_7	...	+06	+11	−09	+10	+04	+15	+01	+06	+19	+08	−11	+01
A_8	...	+07	+11	−09	+11	+04	+16	+02	+07	+20	+09	−11	+02
A_9	...	+07	+12	−08	+11	+05	+16	+02	+07	+20	+09	−10	+02
A_{10}	...	+08	+12	−08	+12	+05	+16	+02	+08	+20	+10	−10	+02
A_{11}	...	+07	+12	−08	+11	+05	+16	+02	+07	+20	+09	−10	+02
A_{12}	...	+07	+12	−08	+11	+05	+16	+02	+07	+20	+09	−10	+02
A_{13}	...	+07	+12	−08	+11	+05	+16	+02	+08	+20	+10	−10	+02
A_{14}	...	+08	+12	−08	+12	+05	+16	+02	+08	+20	+10	−10	+02
A_{15}	...	+08	+13	−07	+12	+06	+17	+03	+08	+21	+10	−09	+03
A_{16}	...	+08	+12	−08	+12	+05	+16	+02	+08	+21	+10	−10	+02
A_{17}	...	+10	+14	−06	+14	+07	+18	+04	+10	+23	+12	−08	+04
A_{18}	...	+10	+14	−06	+14	+07	+19	+05	+10	+23	+12	−08	+05
A_{19}	...	+10	+15	−05	+14	+08	+19	+05	+10	+23	+12	−07	+05
A_{20}	...	+10	+14	−06	+14	+07	+19	+05	+10	+23	+12	−08	+05
A_{21}	...	+09	+14	−06	+13	+07	+18	+04	+09	+22	+11	−08	+04
A_{22}	...	+09	+13	−07	+13	+06	+17	+03	+09	+21	+11	−09	+03
A_{23}	..	+07	+11	−09	+11	+04	+15	+01	+07	+20	+09	−11	+01
A_{24}	...	+06	+10	−10	+10	+03	+15	+01	+06	+19	+08	−12	+01
A_{25}	...	+04	+08	−12	+08	+01	+13	−02	+04	+17	+06	−14	−02
A_{26}	..	00	+04	−16	+04	−03	+09	−05	00	+13	+02	−18	−05
A_{27}	..	...	...	...	...	...	...	...	...	...	...	...	...

Co-ordinates in B.

14	15	16	17	18	19	20	21	22	23	24	25	26	
...	...	...	...	...	...	...	...	...	...	...	...	...	A_1
−06	−23	−23	−21	−17	−12	−07	−32	−31	−29	−46	−41	−31	A_2
−07	−23	−24	−22	−18	−12	−07	−33	−32	−30	−47	−42	−32	A_3
−05	−21	−22	−20	−16	−10	−05	−31	−30	−28	−45	−40	−30	A_4
−03	−20	−20	−18	−14	−09	−04	−29	−28	−26	−43	−38	−28	A_5
−01	−18	−18	−17	−13	−07	−02	−27	−26	−25	−42	−36	−26	A_6
+00	−17	−17	−15	−11	−06	00	−26	−25	−23	−40	−35	−25	A_7
+01	−16	−16	−15	−10	−05	00	−25	−24	−22	−39	−34	−24	A_8
+01	−16	−16	−14	−10	−05	+01	−25	−24	−22	−39	−34	−24	A_9
+02	−15	−15	−14	−10	−04	+01	−25	−24	−22	−39	−34	−23	A_{10}
+01	−16	−16	−14	−10	−05	+01	−25	−24	−22	−39	−34	−24	A_{11}
+01	−15	−16	−14	−10	−04	+01	−25	−24	−22	−39	−34	−24	A_{12}
+02	−15	−16	−14	−10	−04	+01	−25	−24	−22	−39	−34	−24	A_{13}
+02	−15	−15	−14	−10	−04	+01	−25	−24	−22	−39	−34	−23	A_{14}
+02	−14	−15	−13	−09	−03	+02	−24	−23	−21	−38	−33	−23	A_{15}
+02	−15	−15	−14	−10	−04	+01	−24	−23	−22	−39	−33	−23	A_{16}
+04	−13	−13	−12	−08	−02	+03	−23	−21	−20	−37	−32	−21	A_{17}
+04	−13	−13	−11	−07	−02	+03	−22	−21	−19	−36	−31	−21	A_{18}
+04	−12	−13	−11	−07	−01	+04	−22	−21	−19	−36	−31	−21	A_{19}
+04	−13	−13	−12	−07	−02	+03	−22	−21	−19	−36	−31	−21	A_{20}
+03	−14	−14	−12	−08	−03	+03	−23	−22	−20	−37	−32	−22	A_{21}
+03	−14	−14	−13	−09	−03	+02	−24	−23	−21	−38	−33	−22	A_{22}
+01	−16	−16	−15	−11	−05	00	−25	−24	−23	−40	−34	−24	A_{23}
00	−17	−17	−15	−11	−06	−01	−26	−25	−23	−40	−35	−25	A_{24}
−02	−19	−19	−18	−13	−08	−03	−28	−27	−25	−42	−37	−27	A_{25}
−06	−23	−23	−21	−17	−12	−07	−32	−31	−29	−46	−41	−31	A_{26}
...	...	...	...	...	...	...	...	...	...	...	...	...	A_{27}

Spectrum of Nova Aurigæ. By the Rev. W. Sidgreaves, S.J.

[Received and read May 13, 1892.]

My delay in presenting to the Royal Astronomical Society a map of the spectrum of *Nova Aurigæ* needs some explanation. A preliminary map was ready for the meeting in April; but it was so full of details which appeared to me to rest on too slender a foundation, that I decided to wait for a careful re-examination of the two plates exposed on the night of February 3.

Advantage has been taken of the delay to construct a more perfect interpolation curve of wave-lengths. This has been done on a large scale with the aid of two good plates of the spectra of *Arcturus* and *Capella*. And all the lines of the spectrum of the temporary star, together with their wave-lengths taken from the curve, have been subjected to the criticism of two, and in many cases of four, examiners. But I have judged it more prudent to present the map in two forms: of certain and of probable lines. The latter is a development of the former, showing a further resolution of the bands. It may be of service for comparison with similar uncertainties at other observatories, and many of its lines may become by agreement quite unquestionable.

The interpolation curve was constructed from forty-two lines of the spectrum of *Capella*, fairly evenly distributed between D and H. The wave-lengths of these lines were taken from the Report of the British Association of 1878. They are, therefore, those of Ångstrom's map corrected according to the indication set down on p. 29 of his Memoir; and they differ from Rowland's figures by approximately one tenth-metre. The scale-readings are those of a strongly-mounted micrometer screw and magnifier, by Hilger,

dividing to the one-thousandth of a millimetre. A small addition to the stage of the instrument has been improvised to enable the observer to adjust any line on the plate to any desired reading of the scale. The adopted scale-reading for the line F in plotting the curve was 80,000, and in all subsequent measurements the plates have been adjusted with F at this reading; so that the same scale-reading always indicates the same wave-length, and the readings become independent of any possible imperfections of the screw or scale divisions.

The method of photographing the stellar spectra is in some respects the same as the method employed at Harvard College and South Kensington. No slit is used, and breadth is given to the spectrum by trailing the star's image across the plate; but the spectrum is obtained from a small direct-vision prism, by Hilger, at the eye end of the telescope, in place of the large objective prisms of the two other observatories. The prism is carried in a strong brass tube between a collimating lens and an image lens. The apparatus with its slit is an ordinary direct-vision table spectroscope; but its slit is removed, and a small camera is substituted for the eyepiece. The plate-holder is set at an angle of about 20° to the central rays, to obtain uniformity of focus throughout the spectrum. This angle is unchangeable, and all the other adjustable parts are so fixed that an accidental alteration of any of them is hardly possible. The spectrograph is, therefore, practically a rigid tube; its length, including a free space for an additional prism, is twenty-six inches, and it is easily and firmly mounted in a three-rod cradle which was made to carry a heavier spectroscope.

The absence of the slit renders it possible to have the spectrum formed at various angles of incidence upon the prism. And it is important that the incident angle from the Nova should be the same as that from the star which provided the solar lines for the wave-length curve. The instrumental adjustment, on which uniformity of incidence depends, has always been made in the same way. The star is viewed through the prism without the aid of an ocular. Its spectrum then appears as a fairly well defined circular disc cut off by one or both edges of the prism; and this image indicates the adopted adjustment when its segments are equal. An error of adjustment greatly exceeding any probable misjudgment of the equality of the segments—viz. when one of them is reduced to nothing—gives an error in

wave-length of three tenth-metres in the region of G, when F is set to its position on the scale ; so that with moderate care in setting the instrument there is little room for erroneous measurements. But it was not until after the spectrum of the Nova had been photographed that my attention was drawn, while constructing the wave-length curve, to the necessity of care in this adjustment. And when the plates were exposed on the night of February 3 some difficulty had been experienced in adjusting the spectrograph on account of the feeble light of the star and the glare of the Moon. It became, therefore, necessary to discover, if possible, what was the actual adjustment for the incident rays on that night ; and for this purpose a plate was exposed to *α Lyræ* with the two extreme errors of adjustment, already mentioned, successively. The difference of the scale measures from F to G on the two spectra of this plate afforded the means of ascertaining the extreme wave-length error quoted above ; and when the plate was compared with that of the Nova by placing their films and edges together, the line F of the latter was found to be midway between the two positions of F in the former. This was considered satisfactory evidence of the correct adjustment of the instrument for the Nova ; but the hydrogen lines at G′ and *h* appeared out of their places on the map, and to bring them right it was necessary to adopt one of them for a second fiducial point for the application of the wave-length curve. This operation was equivalent to an admission that the spectrum of the Nova had not been in its right place upon the plate ; and another series of experimental photographs became necessary to determine what departure from the usual adjustment of the spectrograph would give the linear measure from F to *h* on the spectrum of *α Lyræ* the same as on the spectrum of the Nova. The result was a maladjustment quite outside any admissible probability ; and therefore the only course open to us at present is to give the wave-lengths as they come out on the supposition that the instrumental adjustment was correct. But a third column has been added to the table to show the wave-lengths of the bright lines altered to suit the supposition that the centres of the bright bands at F and *h* are the true positions of the wave-lengths 4861 and 4101.

Table I. contains, first of all, two double columns, in order to present separately the two catalogues of the minimum and maximum resolution of the spectrum, and to separate the absorption from the radiation bands or

ines, as possibly belonging to different stars. The additional column just mentioned follows, and a column of "Remarks" concludes the Table.

In the first double column only those bands or lines are entered which are easily recognised upon the plate. The second double column gives the results of a very careful and prolonged study of the details of two plates exposed to the Nova on the night of February 3. It represents the independent judgments of two experienced assistants of the late Fr. Perry—viz. Fr. Cortie and Mr. W. McKeon—and contains only those lines which have been detected by each examiner on both plates. In the column of remarks some other lines have been added as possible lines. These have appeared very probable to the examiners, but are wanting the confirmation of both plates.

The most striking features of the plates are the bright and dark companion bands, and their great width. It is quite impossible to attribute the dark bands at F and G′ to contrast effect. The photographic action has been *nil* at these positions, perfectly clear glass being left to mark the spaces.

Some doubt has existed as to the reality of the width of the bands as they appear upon the plates. The long exposure needed by the small optical power employed upon a star of the fifth magnitude might be expected to bring out the effects of scintillation as a wide band instead of a comparatively narrow line. This is undoubtedly true in principle, and is shown on both the plates exposed on February 3. But the effect becomes appreciable only when the exposure has been excessively long. Excessive exposure happened in the middle of the trail on the first plate through a temporary alteration in the rate of the clock while the star was near the meridian, and at the beginning of the second trail owing to an attempt to obtain a slower passage of the star's image. At these positions the image was stationary for about twenty minutes, and the exposure consequently becomes incomparable with that of the moving image. The bright lines are here clearly wider than on the trailed spectrum, but less so than they appear to the unaided eye. The microscope shows approximately where the fault begins, and the measure of the width on the stationary part differs little from the measure given by the trail. We have further evidence for the truth of the wideness from the photographs of other stellar spectra. A recent exposure upon γ *Cassiopeiæ* at its northern transit, while the star was scintillating greatly in its low

altitude, gives all the lines with unimpaired definition, quite equal to that of the best impressions obtained from the star when close to the zenith ; and on another plate, exposed to the star at the same low altitude, a trailing rate even slower than was employed on the Nova has failed to leave its mark upon the bright F line.

The companion bands, as exhibited in the simpler map and in the first double column of the table, amply confirm the estimates from other observatories of the high differential velocities to be reckoned with in any account of the origin of the new star. The mean radial component of this velocity, from the thirteen pairs of bright and dark bands, is, roughly, 550 miles in the second, under the presumable supposition that each pair is a radiation and absorption of the same origin. But there is a considerable discordance between the individual measures, ranging from 400 to 650 miles. Some of these divergencies may be pulled together when reconsidered under the light that may be thrown upon them by the finer though less certain details of the spectrum, or they may claim to be real differences.

All the wave-lengths assigned to the lines of the spectrum are referred to the position of F on the scale, and the middle of the broad bright band as it appears on the plate was adopted for the true place of the line 4861 of the bright-line star.

This was an arbitrary selection of the fiducial point, and the point might be shifted to suit the claims of any other lines. Two other positions seemed of themselves probable—one near the marginal separation of the bright from the dark band, the other more remote from it. The first of these would favour a single-star hypothesis. The second claims attention on the following grounds : the actually adopted position of F on the map is the middle of the bright band as it appears on the simpler map, and is very closely that of the dark dividing line of the more detailed map. But a closer examination of the plate revealed a feebler wing on the red side of the band, and, supposing this to be a part of the hydrogen band, its tenth-metre breadth becomes more nearly the same as that of G′, and its centre falls to the red side of the adopted position of F on the map.

The importance of these alternatives cannot be exaggerated. The true position of F is the key to both the problems contained in the spectrum—the origins of the lines and the cause of the outburst. If this position be

anywhere near the middle of the bright band we have the high velocities of a pair of stars, indicating that their near approach, either with or without collision, was the cause of the new illumination in the sky ; for we have two fiducial points, one for the bright bands, another for their dark companions. But if the third position, at the marginal separation of the bright and dark hydrogen, can show a better claim to the wave-length 4861, we must accept it as the fiducial point for both the dark and the bright bands, and look for the cause in a disturbance, however brought about, of a single star at comparative rest; the widening of the lines must be attributed to circular velocity in a plane or planes not greatly inclined to our sight-line, and the advancing parts of the whirling gases must be covered by a sufficient depth of absorbing medium to give the dark bands. A great cyclonic storm of heated gases rushing towards us in the lower atmosphere of the star, trending upwards and returning over the stellar limb in the higher regions, would satisfy all the requirements of the spectrum, and might meet with favour if only we could accept the form of disturbance, the high velocities, and six weeks' duration as probabilities. But if we estimate possibilities in the heated atmosphere of a giant star by the velocities and durations of some of the destructive cyclonic hurricanes in the cold atmosphere of our little Earth, we can hardly deny possibility to this origin of the spectrum.

In order to gain some directing evidence for the right selection of the position of F, the better-known bands of the photographed spectrum have been selected for comparison with their known wave-lengths, as given in Professor Young's catalogue of solar chromospheric lines. The comparisons have been made on the following plan, and are given in Table II.

In each column the wave-lengths are quoted for the parts of the bands most nearly corresponding with the position of F in the hydrogen band. These positions are, for columns 1, 2, 4 and 5, the middles of the bands, corresponding with the two possible middles of the F band already noted; and for columns 3 and 6 the more refrangible edges of the bands. Of the six columns thus obtained, the first three, under A, show the wave-lengths obtained from the catalogues of lines as given by the instrument, and the rest, under B, refer to the same lines corrected for the possibly erroneous position of the spectrum on the photographic plate.

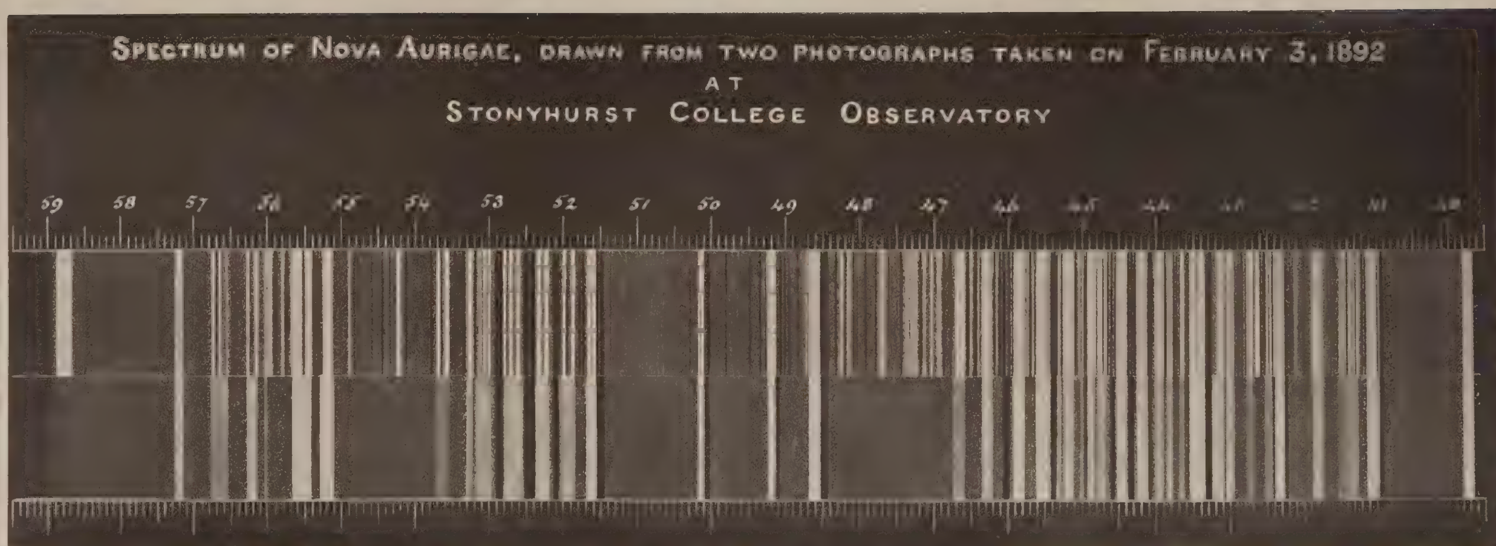
According to this analysis of the spectrum, the choice lies between the

PHOTOGRAPHED SPECTRUM OF NOVA AURIGAE,

ENLARGED.

2.8 DIAMETERS.

5.6 DIAMETERS.



Woodbury Company (Eyre & Spottiswoode).

assertions of columns 3 and 4. The figures in column 4 show very well on the whole; but G′ is out of its place, and this line should have considerably greater weight in the balance than any of the others. The figures, too, are based upon a supposition (B) which all our experiments have failed to confirm. Column 3, on the other hand, shows a good list of wave-lengths, with G′ in its place, and the figures are free from the fundamental alteration of the map, which was suggested only by a natural prejudice in favour of the middle of the band for the position of F. Column 3, therefore, appears with the best claims to acceptance, and it places the true position of F at the marginal separation of the bright and dark pair of bands. We do not contend that it decides the consequence—that the source of the spectrum is in a comparatively stationary star—but only that so far as our photographs contribute to the collective evidence, their weight is in favour of the unity of *Nova Aurigæ*.

TABLE I.

Wave-length Catalogue of Lines in the Spectrum of Nova Aurigæ.

Unresolved Bands.		Probable Lines.		Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks. (Figures here refer to the double column of Probable Lines.)
Bright.	Dark.	Bright.	Dark.		
3974	...	3967 to 3980		3961 to 3974	In one photograph four intensities were seen in this band—viz., at 3967, 3970, 3977, and 3980. The extreme of sensibility in the plate.
	4095	...	4092 to 4097		Bright lines seen with difficulty in one photo. at 3999, 4005, 4028, 4032, 4043, 4053, 4066, 4077, and a dark line at 4089.
		4098		4094	Resolution of this band very difficult in one plate, but easy in the other.
			4100		
4105	...	4104		4100	
		4108		4104	
			4110		
		4112		4108	Photos. begin to get strong.
			4115		
			4120		
		4126		4123	An extremely faint and badly defined group; details most difficult in both plates. A fine absorption line suspected at 4147.
			4129		
		4131		4128	
4138	...	4137		4134	
			4141		
		4144		4140	
		4150		4146	
			4158		
			4162		
			4165		
			4173		
		4175		4171	Resolution difficult, but the results from both plates agree well together.
		4178		4174	
4180	...		4180		
		4183		4179	
		4186		4182	Probably a fine absorption between two bright lines at 4185.
			4192		
			4200		
		4211		4206	A very faint line. Both photographs show a group of very faint bright lines extending from 4202 to 4217; but definition too poor for certain identification or measurement.
			4215		
			4218		
	4224	...	4222		
			4226		

TABLE I.—*continued.*

Unresolved Bands. Bright.	Unresolved Bands. Dark.	Probable Lines. Bright.	Probable Lines. Dark.	Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks.
		4229		4226	Results from the two plates very difficult to reconcile between 4229 and 4250.
4234	...	4232		4229	
		4236		4232	
		4241		4238	
			4243		
		4246		4243	
4248	...		4248		
		4250		4247	
			4255		
			4260		
		4264		4261	4264, a faint broad line with probably two intensities.
		4270		4267	
4274	...	4273		4270	
		4277		4274	
			4279		4283, 4287, and 4292 seem very probably to be fine bright lines, inasmuch as they appear slightly stronger than the continuous spectrum on both photos.
			4284		
			4289		
			4295		
		4298		4295	
4301	...	4304		4301	
		4312		4309	Fine dark lines on one plate at 4309 and 4319.
4316	...	4317		4314	A faint and somewhat doubtful bright line at 4321.
	4331	...	4325 to 4336		Two intensities seen, with great difficulty, in this band.
		4338		4335	Exceedingly bright.
		4343		4340	" " A close double clearly seen in one plate.
4346	...	4348		4345	" "
		4351		4348	" "
		4355		4352	A winged ray.
		4364		4362	A close double very faint.
4366	...	4367		4365	
			4368		
			4373		
			4377		
4382	...	4380		4378	Faint lines.
		4384		4382	

Table I.—*continued.*

Unresolved Bands.		Probable Lines.		Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks. (Figures here refer to the double column of Probable Lines.)
Bright.	Dark.	Bright.	Dark.		
			4388		
		4391		4389	
4396	...	4396		4394	
		4400		4398	
			4407		
	4409	...			
			4411		
		4414		4412	
4419	...	4419		4417	A suspected double.
		4424		4422	
			4428		
	4433	...	4433		
			4438		
		4443		4441	
4447	...	4447		4445	Very difficult to be certain of details.
		4452		4450	
			4454		
	4460	...	4460		
			4466		
		4467		4465	
			4471		
4472	...				
		4474		4472	A close double.
		4477		4474	
			4480		
		4486		4484	
4488	...				A very strong and a fine line close together.
		4491		4489	
			4495		
	4496	...			
			4497		
		4500		4497	
4502	...				
		4505		4503	
			4510		
		4512		4510	
		4516		4514	A very bright line.
4519	...				
		4521		4519	,, ,, Possibly a fine absorption between two bright lines at 4523.
		4525		4523	
			4528		
4531	...	4531		4529	
			4534		A very fine faint absorption.
	4540	...	4537		A fine but very dark line.
			4542		

TABLE I.—*continued.*

Unresolved Bands. Bright.	Unresolved Bands. Dark.	Probable Lines. Bright.	Probable Lines. Dark.	Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks.
		4546		4544	
			4547		
4553	...	4550		4548	A strong and very bright line.
		4555		4553	" " "
		4560		4558	A probable absorption line at 4564.
			4565		
		4568		4565	Fine faint line.
			4570		A fine but very dark line.
		4573		4572	Fine and rather faint.
		4579		4577	
4585	...	4585		4583	Three very bright lines.
		4591		4589	
			4593		Most probably a bright line at 4596.
	4603	...	4599		
			4606		
			4612		
		4616		4613	
			4618		
		4623		4620	A winged ray.
4629	...	4630		4627	Strong line; a suspected double.
		4634		4631	A winged ray.
		4641		4638	
			4643		
		4651		4648	
			4655		
		4662		4660	Faint line.
4666	...	4668		4667	" "
			4677		
			4687		
		4694		4693	Between 4694 and 4826 the bright lines were extremely faint and difficult to distinguish from the continuous spectrum.
		4704		4702	
		4714		4711	
			4718		
		4725		4723	
		4731		4730	
		4737		4736	A fine absorption probable on one plate at 4701.
			4745		
			4761		
		4767		4766	

Table I.—*continued.*

Unresolved Bands.		Probable Lines.		Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks. (Figures here refer to the double column of Probable Lines.)
Bright.	Dark.	Bright.	Dark.		
		4773		4774	A fine absorption probable at 4787, and a faint bright line at 4798.
			4778		
			4793		
			4805		
			4810		
		4815		4816	
			4820		
		4826		4827	
			4833		
	4849	...	4843 to 4855		Two intensities seen with great difficulty in this band, one at either edge. Near to the minimum of sensibility in the plate.
4861	...	4858		4858	Remarkably bright lines.
		4864		4864	
		4872		4872	A winged ray. Possibly fine absorption lines at 4862 and 4869.
			4883		
			4895		
			4901		
	4910	...	4907 4913		Two intensities in what is possibly but a single broad line.
4920	...	4916		4916	Very bright line.
		4920		4922	" "
		4926		4928	A winged ray.
			4928		
			4935		
			4949		A broad line faintly bright on one plate at 4954.
			4962		
			4968		
			4980		
	5006	...	5002 to 5010		Broad line, with two intensities.
5014	...	5012		5014	A close double very bright.
		5016		5018	
			5029		A fine absorption probable at 5023, and another at 5050.
			5062		
			5069		
			5085		Broad lines very faintly bright on one plate at 5043 and 5072.
			5098		
			5114		

TABLE I.—*continued.*

Unresolved Bands.		Probable Lines.		Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks.
Bright.	Dark.	Bright.	Dark.		
			5126		
			5136		Faint bright lines probable at 5093, 5103, 5123, 5130, and 5141.
			5145		Impossible to be certain whether these are distinct lines or one broad band with two intensities. The latter seems to be the more probable.
	5151	...	5157		
5163	...	5159		5163	A strong and very bright double.
		5166		5170	
			5174		5176 is possibly a faint bright line between two absorptions.
			5178		
		5187		5190	5187, a very faint line, intensity but slightly greater than the continuous spectrum.
5193	...		5196		
		5199		5202	
			5205		
	5210	...	5214		
5228	...	5221		5224	A strong and fairly bright pair.
		5232		5235	
			5240		
	5245	...	5250		
		5260		5263	5257 is possibly a very fine line faintly bright.
5269	...	5271		5274	
		5279		5282	
			5282		
	5286	...	5290		
		5299		5302	
5308	...	5306		5309	
		5313		5318	
			5320		
5326		5326		5334	Strong line and very bright.
			5335		
			5347		
		5357		5363	A rather faint double, with an absorption between.
5364	...		5365		
		5369		5374	
			5379		5395, a fine line faintly bright on one plate.
			5413		
		5423		5429	5416 " " "
			5435		Line 5423 is faint.
			5445		At 5464 and 5478 bright lines were clearly seen on one plate, and a dark line at 5470.
			5459		

Table I.—*continued.*

Unresolved Bands.		Probable Lines.		Bright Lines corrected for a Foreshortening of the Photo-spectrum by its possible faulty Position on the Plate.	Remarks. (Figures here refer to the double column of Probable Lines.)
Bright.	Dark.	Bright.	Dark.		
			5483		
		5489		5495	A fine faint line.
5520	...	5513 to 5524		5521 to 5532	A very bright band in which a division was suspected, but not clearly seen.
			5540		At 5502 a bright line clearly seen on one plate, and a fine absorption line at 5507.
5555	...	5542 to 5549		5551 to 5558	5542 to 5549 is a very bright band; double on one plate.
		5555 to 5567		5564 to 5576	5555 to 5567 very bright. On one plate two lines were seen certainly, and three suspected in this band.
			5576		5534 and 5553 are probably fine absorption lines.
		5581		5590	Line 5581 is very faint.
			5591		
		5597		5606	5597 is broad but faint.
5603		5603		5612	
5621	...	5616		5625	
		5627		5636	Fine absorption lines probable at 5611, 5648, 5660, and 5685.
5666	...	5656		5666	
		5665		5675	
		5675		5685	
5721	...	5716 to 5726		5729 5739	A faint band too difficult to resolve.
5879	...	5869 to 5888		5885 to 5904	On one plate two maxima were seen in this band, viz. at 5870 and 5887; also a winged ray at 5861 and another at 5893.

Probable bright lines were seen on one plate at 5739, 5763, 5784, and 5797; and dark lines at 5760, 5814, 5840, and 5902.

The band 5879 occurs about the extreme of sensibility in the plate. Yet other lines were discernible beyond D, but all were too faint to measure.

TABLE II.

A								B				Chromosphere.
1	d	2	d	3	d	4	d	5	d	6	d	
3974	−6	3973	−5	3969	−1	3968	0	3967	+1	3963	+5	H 3968
4105	−4	4104	−3	4100	+1	4101	0	4100	+1	4097	+4	*h* 4101
4346	−6	4345	−5	4340	0	4343	−3	4342	−2	4337	+3	G′ 4340
4472	−1	4470	+1	4470	+1	4470	+1	4468	+3	4468	+3	*f* 4471
4861	0	4861	0	4861	0	4861	0	4861	0	4861	0	F 4861
...	...	...	...	4921	0	..	...	...	...	4923	−2	* 4921
4920	+2	4917	+5	...	...	4922	0	4919	+3	...	...	† 4922
...	...	...	...	5016	−1	...	...	...	...	5018	−3	* 5015
5014	+2	5011	+5	...	...	5016	0	5013	+3	...	...	† 5016
5163	+4	5160	+7	5165	+2	5167	0	5164	+3	5169	−2	b_4 5167

A Wave-lengths as given by the instrument.
B Wave-lengths as corrected for the possible foreshortening of the spectrum on the photographic plate.
1 & 4 Wave-lengths of the middles of bands, as given by F at the middle of the band on the simpler map.
2 & 5 Wave-lengths of the middles of bands, as given by F at the middle of the wider band on the more detailed map.
3 & 6 Wave-lengths of the more refrangible edges of bright bands, as given by F at the more refrangible edge of the bright band.
Chromospheric wave-lengths from Dr. YOUNG's Catalogue.
d Difference between the wave-lengths of the chromospheric lines and the wave-lengths of the preceding column.
* More refrangible line
† Mean of pair

Physical Observations of Mars, made at the Allegheny Observatory in 1892.

By James E. Keeler, D.Sc.

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During the summer of 1892 Mars was observed at the Allegheny Observatory with the thirteen-inch refractor on every favourable occasion. Up to the time of opposition, and for several days thereafter, cloudy weather prevailed. The sky then cleared, and during the rest of the favourable season there were many fine nights on which the definition was really excellent, so that the highest powers of the telescope could be used to advantage.

The object of the observations was to make a series of drawings of the surface features of the planet, and to compare the maps of Schiaparelli, Green, and other observers with what could actually be seen in the telescope. With this end in view, I first made a globe of Mars, six inches in diameter, from the chart accompanying Professor Schiaparelli's article in Vol. I. of *Himmel und Erde*.* This chart was prepared by Professor Schiaparelli from his observations of Mars in the oppositions 1882–88. The globe was much more suitable than a map for direct comparison with the image in the telescope.

Each drawing was made on a previously prepared outline, on which the phase of the planet for the time of observation was indicated. After the drawing was completed, and when I was satisfied that I could not

* Also reproduced on p. 440 of Flammarion's *La Planète Mars*.

improve it, I compared it with the globe, and endeavoured to determine whether the differences were due to my errors of drawing, incorrect perception of the nature of the markings, or to real changes on the surface of the planet. The drawing was in any case allowed to remain unchanged, the conclusions in regard to the cause of the differences being added in the form of notes. Thirty-one drawings were obtained in all.

These drawings were, as nearly as circumstances would permit, pictorial representations of the surface of Mars, the relative intensities and different degrees of definiteness of the markings, as well as their outlines, being reproduced according to the best of my ability. A line diagram has always seemed to me to be a most unsatisfactory representation of such markings as those on Mars, as likely to give a false as a true idea of what was seen, and at the best conveying only a part of the truth. The exact place at which a sharp boundary line should be drawn to represent a gradual transition from light to shade occupying a surface of considerable width, must be to a large extent arbitrary, and probably no two observers would agree in fixing it. Although some of the markings on Mars have sharp outlines, there are others which shade off by imperceptible transitions into their surroundings. Such markings are, indeed, characteristic features of the surface of Mars, and as they are not readily explained, it is important that they should be recorded as faithfully as possible in drawings. The admirable drawings of Mr. Green owe much of their value to the care which has been bestowed on the appearance of the different features, and their general agreement with views of Mars in both large and small telescopes is doubtless due to the same reason. It seems to me that the habit of representing indefinite boundaries by sharp lines, and neglect to preserve a uniform scale of relative intensity, are responsible for most of the discrepancies in drawings which are ascribed to personality of the observer in interpreting faint markings.

In the drawings which I made I tried to keep the same scale of intensity throughout the series. If there was not time enough at the telescope to finish a drawing on this plan, the relative intensities, and such corrections as were required, were indicated in the notes.

All positions of markings in the drawings are from eye estimates. A power of 380 was generally employed, although sometimes the definition permitted the use of a power of 800 for some special purpose. Lower powers

were also used, but no drawings were made when the seeing was not good enough for the power of 380. As Mars was low in the southern sky, it was often seen through a thin veil of smoke, arising from the city in the valley below the observatory ; but although the brightness of the image was diminished, the definition under these circumstances was frequently excellent. The satellites were seen on a number of occasions.

After all the drawings were made, they were compared with the globe in the following manner. The globe was mounted at one end of a wooden slide or board, in such a manner that its axis could be inclined at any desired angle. A camera was also mounted on the slide, with the lens at the same height above the board as the centre of the globe. The camera was adjusted until the image of the globe was reduced to the size of the drawings (two inches diameter), and clamped in that position. A thread was stretched across a frame so that it was tangent to the nearest point of the globe, and parallel to its axis. On the image it appeared as a fine line bisecting the disc and passing through the poles; *i.e.*, as a visible central meridian. The globe was set so that the central point of the image had the latitude and longitude of the centre of Mars at the time of observation, according to MARTH's ephemeris,* and then photographed with a small stop. The photograph obtained in this way was not, of course, an orthographic projection of the globe; but over the central portions of the disc, where alone the markings were distinctly shown on the drawings, the distortion was imperceptible, or much less than the errors of observation.

It is evident that if there were no errors in the globe or drawing, and if no changes had taken place in the markings of the planet, the photograph and the drawing should exactly coincide when superposed. Comparisons could thus be made in a very satisfactory manner, and the meridians and parallels on the photographs afforded an excellent test of the consistency of the drawings.

It was found that there was a very satisfactory agreement among themselves in the positions of the markings on the various drawings, but that there was a small and nearly constant difference of longitude between the drawings and the photographs of the globe, the longitude of the central meridian on the latter exceeding that of the drawings by about seven degrees. I, therefore,

* *Monthly Notices R.A.S.*, vol. lii. p. 398.

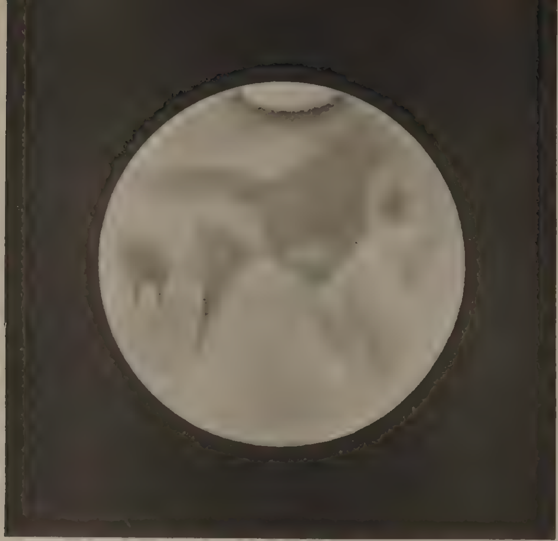
made another set of photographs, with slightly different positions of the globe, according to the following plan. The axis of the globe was set to the proper inclination, so that the latitude of the centre of the image was that of the centre of Mars at the time of observation. The globe was turned on its axis until the image on the ground glass was in the best general agreement with the drawing made at that time, and the image was then photographed, as before. The agreement of the drawings and photographs, in their main features, was then remarkably close.

I am unable to account for this constant difference of longitude. The most natural explanation is that it is due to constant error in estimating the position of the diameter of a large disc ; but, according to other experiments, my personal error of estimated bisection is too small to account for the difference.

Twelve of the thirty-one drawings were selected as representative, and copied in India ink, with due regard to the notes which had been made about intensity of shading, etc. All the drawings were, however, utilized in the preparation of the copies ; for when, as frequently happened, several nearly identical views were obtained on consecutive nights, the mean of the positions of a marking obtained by these independent estimates was taken for the position of that marking on the copy ; that is, the drawings of any one part of the planet were treated in the same way as other independent observations of the same quantity. It should be mentioned, however, that drawings separated by an interval of more than two days were not combined in this way, as real changes in the surface features of the planet might otherwise be treated as accidental.

The twelve drawings in India ink are reproduced in the accompanying plates. They are arranged in the order of decreasing longitude, and nearly in chronological order. On the left of each drawing is given the computed longitude of the central meridian (of the entire disc) for the time of observation, and on the right the longitude, determined from the Schiaparelli globe, which best represented the general aspect of the drawing. Eastern standard time, used at the Allegheny Observatory, is five hours slow of Greenwich mean time.

The drawings make a detailed account of the observations unnecessary. A few explanatory notes are, however, given below.



50° 7. 44°.

1. 1892 AUG. 17$^{d.}$ 11$^{h.}$ 55$^{m.}$

30° 4. 26°.

2. 1892 AUG. 17$^{d.}$ 10$^{h.}$ 32$^{m.}$

270° 6. 261°.

5. 1892 AUG. 29$^{d.}$ 9$^{h.}$ 42$^{m.}$

235° 6. 251°.

6. 1892 SEPT. 2$^{d.}$ 9$^{h.}$ 47$^{m.}$

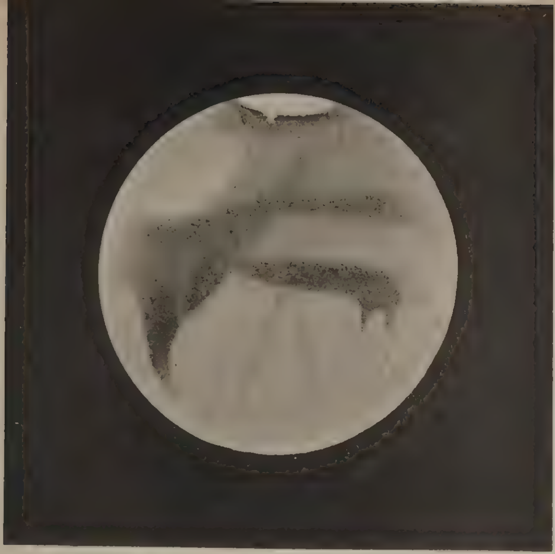
157° 1. 150°.

9. 1892 SEPT. 9$^{d.}$ 8$^{h.}$ 47$^{m.}$

134° 9. 130°.

10. 1892 SEPT. 11$^{d.}$ 8$^{h.}$ 31$^{m.}$

EASTERN

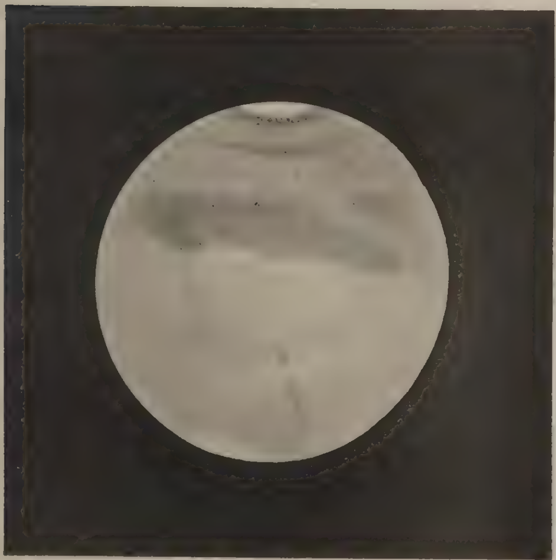


334° 6. 327°.

3. 1892 AUG. 22$^{d.}$ 9$^{h.}$ 46$^{m.}$

295° 5. 287°.

4. 1892 AUG. 29$^{d.}$ 11$^{h.}$ 24$^{m.}$

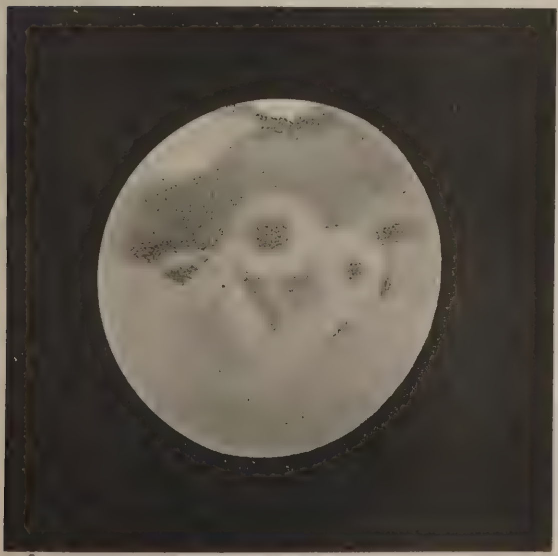


211° 7. 200°.

7. 1892 SEPT. 3$^{d.}$ 8$^{h.}$ 46$^{m.}$

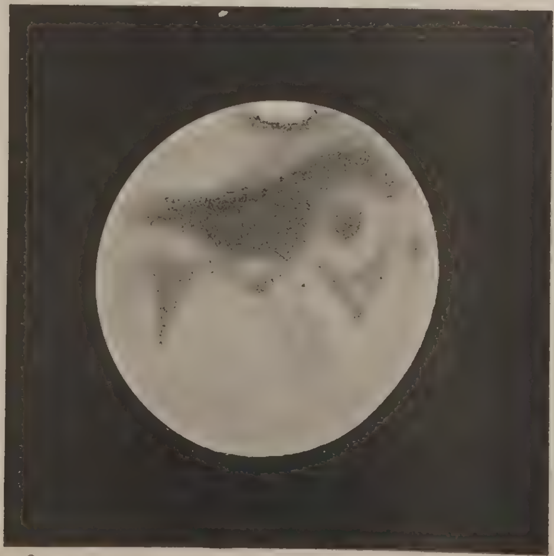
177° 8. 170°.

8. 1892 SEPT. 6$^{d.}$ 8$^{h.}$ 19$^{m.}$



93° 7. 89°.

11. 1892 SEPT. 18$^{d.}$ 10$^{h.}$ 8^{m}



71° 1. 60°.

12. 1892 SEPT. 17$^{d.}$ 7$^{h.}$ 57$^{m.}$

Notes on the Drawings.

No. 1 and *No.* 2, *August* 17.—This part of the planet was well seen. *Deucalionis Regio* and *Pyrrhæ Regio* are somewhat dusky, although still quite bright. They seem to unite and form a single bright spot, without any line of separation. The part of the *Sabæus Sinus* which is shown is the darkest part of the disc, except, perhaps, the narrow shade just below the northern rim of the snow cap. The *Auroræ Sinus* is broad and shallow, and a dusky island, bright in the centre, stretches across it. A broad, ill-defined shade, in which there appear to be two dark maxima, stretches away from the eastern shore of the bay to the n.p. limb of the planet.

In *No.* 2 a projection, or possibly a small detached spot, is seen on the border of the snow cap, almost on the limb. Below the snow cap, the upper part of the disc is occupied by a large bright spot or island which covers the chain of islands, *Noachis*, *Argyre*, and *Argyre II.* From a comparison of all the drawings on which this marking occurs, the lower boundary of this large island seems to follow pretty closely the northern and eastern outline of the chain as it is marked on the globe.

The *Solis Lacus* in *No.* 1 is grey, and a little darker than any part of the *Mare Erythræum.*

No. 3, *August* 22.—The outlines in this drawing agree closely with those on the photographed globe. The most striking differences are the brightness and greater size of *Hellas* on the drawing, and the abruptness with which the *Deucalionis Regio* and the *Pyrrhæ Regio* end on the west, nearly in line with the east shore of the *Syrtis Magna. Hellas* is connected by a dim half-shade with the island described in the last note. Its increase in size seems to be mainly on the sides and toward the south, as the northern boundary is in latitude $-30°$, the same as on the globe.

The *Phison* and the *Euphrates* appear as faint streaks. A projection of the snow cap is shown, evidently the same as that in No. 2.

No. 4, *August* 29.—The *Syrtis Magna* is central. It is much the darkest marking on the disc. The darkest part terminates above in a point, the small angular area there being bounded on the right by a dusky half-shade (*Œnotria*), and on the left by another (the lower part of *Ausonia*). I have

not been able at any time during this opposition to trace the *Syrtis Magna* to the lower end, where it curves away sharply to the right. Above, and also central, is *Hellas*, large and bright, like the Lockyer Land of Green's chart.

No. 5, *August* 29.—Made a little earlier on the same evening with *No.* 4. The *Syrtis Magna* is on the right. Both *Ausonia* and *Hesperia* appear as dusky streaks or bridges, only a little brighter than the surrounding ocean, and not at all conspicuous. *Hesperia* agrees well in outline with the globe, but *Ausonia* extends farther down than on the globe, curving around the east coast of *Libya* and reaching well into the mouth of the *Syrtis Magna*.

No. 6 and *No.* 7, *September* 2.—*Hesperia* is central. In this, and in the next three drawings, no part of the disc above the outline of the continent (except the snow cap) is as bright as the lower part of the disc. Nearly the whole of the southern hemisphere is dusky.

The channel *Xanthus* is quite conspicuous, but the islands *Thyle I.* and *Thyle II.* above it are blended into a narrow dusky strip, as in Green's chart.

From the *Mare Cimmerium* extends a fairly conspicuous dark streak, which is more like the Huggins' Inlet of the older maps than any of the canals on the globe. It is considerably inclined to the meridian. Below, and connecting with this, is a system of narrow streaks or canals which I have not been able to certainly identify with anything on Green or Schiaparelli. In a drawing made with a small telescope by Giovannozzi,* there is a canal which agrees almost exactly in position with the canal which I have drawn nearly radial in *No.* 7. The break in this canal, or bridge across it, seemed to be part of a bright streak which extended some distance on each side of the canal.

No. 8, *September* 6.—The lower end of the *Mare Sirenum* is central. I could not see any narrow strip or bridge corresponding to Schiaparelli's *Atlantis*. There was, however, at the angle of the coast line just above, a dusky half-shade projecting a short distance into the ocean, in a very indefinite direction, which may have been the lower part of this marking. It is shown in both *No.* 7 and *No.* 8.

No. 9 and *No.* 10, *September* 9 and *September* 11.—These drawings show the *Lacus Solis*, and another dark spot which will be described in connection

* *Memorie della Pontificia Accademia dei Nuovi Lincei*, t. vi. Reproduced in *La Planète Mars*, p. 478.

with *No.* 11 and *No.* 12. *Icaria*, *Phœtontis*, and *Electris* are shown as a single uniform streak, somewhat dusky, but fairly bright. Below this streak, in the *Mare Sirenum*, the ocean is considerably darker than above it, and darker than at any other part of the disc. The markings on the continent are very broad and diffuse.

No. 11 and *No.* 12, *September* 17 and *September* 18.—Since the last opposition, two years ago, some most interesting changes in the surface of Mars appear to have taken place in the region of the *Solis Lacus*, which is shown in these two drawings. Views were obtained of this region on a number of fine nights, and showed some remarkable differences in the appearance of the markings, as compared with their appearance on the globe.

The ring of land (*Thaumasia*) surrounding the *Lacus Solis* is narrower than it is on the globe, and as comparison with the photographs shows that the central dark spot has not changed in size, this appearance seems to be due to encroachment of the surrounding ocean. This narrowing of the ring from the outside would also account for the greater shallowness and otherwise changed shape of the *Auroræ Sinus*. The upper half of *Thaumasia* was somewhat dusky, and not so bright as the lower half. I sometimes suspected an opening in the ring on the left, but could not be sure of its reality. In making drawing *No.* 12 it was noted that the snow cap was of about the same size as the *Solis Lacus*.

A remarkable feature, not on SCHIAPARELLI's map, was a dark spot, somewhat like the *Solis Lacus*, but not so large as the latter, which is shown on the right of the *Solis Lacus* in both drawings. It seems to be too far from the *Solis Lacus* to be the *Lacus Phœnicis*, although it is in the right direction. On several evenings about September 18 it was noted that when this spot was on the central meridian it occupied the exact centre of the disc of Mars, and that when so situated the distance between the centres of the two spots was just one-half the radius of the disc. This observation would give for the position of the new spot, by comparison with the place of the *Solis Lacus* on the globe, lat. = – 13°, long. = 113°. Still farther on the right, at about half the distance of the *Solis Lacus*, was a smaller dark spot of irregular shape, which was part of a narrow streak extending toward the north-west.

Below the *Solis Lacus* was a broad dark shade of the shape shown in the

drawing, crossed by a narrow dusky bridge. The colour of this dark area was a dusky red, quite different from the grey of the *Solis Lacus.* The parts of the continent bordering on the dark area were very bright and red.

The broad shading extending downward from the *Auroræ Sinus*, shown in drawings *No.* 1 and *No.* 2, is also shown in these drawings. In the bright angular area just above this shading a minute dark speck, probably the *Fons Juventæ*, was noticed on two occasions. According to the globe it has been placed too high in the drawings. Another small projection from the polar snow cap is shown, in longitude 100°.

According to the drawings the eccentricity of the polar cap was quite small.

At no time was I able to detect a double aspect in any of the few canals shown in the drawings, unless the two maxima of the shade represented in drawings *No.* 1 and *No.* 12 may be regarded as a doubling of the *Ganges.*

Comparison of the Greenwich Ten-Year Catalogue (1880) *with the Cape Catalogue* (1880).

By H. H. Turner, M.A., B.Sc., and H. P. Hollis, B.A.

Received April 11; read April 14, 1893.

The whole of the work involved in the following pages was done as a part of the regular work of the Royal Observatory, Greenwich. Mr. Hollis superintended the reductions and commenced the discussion of refraction. The whole was revised and completed by myself, and I am responsible for any opinions expressed in the latter part of the paper. It is the wish of the Astronomer Royal that the paper should be communicated to the Society in our joint names.

H. H. T.

There are 762 stars common to the two Catalogues. The excesses of the Greenwich results for R.A. (reduced to equatorial interval) and N.P.D. over the Cape results were formed for each star, and the differences arranged (1) in order of R.A., (2) in order of N.P.D. Weights were assigned to the differences of R.A. according to the formula

$$\frac{4mn}{m+n+\frac{1}{5}mn},$$

where m and n are the numbers of observations of the star in the respective Catalogues. The extreme weight for any one star thus never exceeds 20, which corresponds to an infinite number of observations in both Catalogues,

and a systematic error is thus not allowed to influence the results unduly. The differences of N.P.D. were weighted according to the formula

$$1 \Big/ \left\{ \frac{e^2}{2m} + \frac{e'^2}{2n} + (0''\cdot 16)^2 \right\}$$

where e and e' are the probable errors of observation for the zenith distances at the two observatories, and m and n the numbers of observations. [See Mr. STONE's paper, *Monthly Notices*, 1869 June 11, p. 324.]

TABLE I.

(1) *The Comparison in order of R.A.*

Limits of R.A.	Diff. of R.A. × sin N.P.D. G−C.	Weight.	Diff. of N.P.D. G−C.	Weight.
h h	s		"	
0–1	+·030	209	+0·44	232
1–2	+·008	152	+0·47	188
2–3	+·020	207	+0·63	223
3–4	+·018	241	+0·33	256½
4–5	−·005	204	+0·47	229
5–6	−·003	291	+0·44	335
6–7	+·027	253	+0·22	252
7–8	+·011	239	+0·32	233
8–9	+·005	172	+0·36	201½
9–10	−·001	170	+0·42	163
10–11	+·008	168	+0·70	151
11–12	+·012	182	+0·21	199
12–13	+·012	182	+0·33	149
13–14	−·007	226	+0·41	161
14–15	−·001	146	+0·40	117
15–16	+·001	183	+0·16	178
16–17	+·010	220	+0·36	191
17–18	+·030	203	+0·46	184
18–19	+·031	249	+0·76	225
19–20	+·022	243	+0·74	267½
20–21	+·040	173	+0·53	169
21–22	+·032	169	+0·86	179
22–23	+·029	276	+0·51	300
23– 0	+·021	206	+0·49	244

There is apparently a systematic difference in N.P.D. nearly constant throughout the 24 hours of R.A. The mean value

	h h		″
for	0–6	is	0·46
	6–12	is	0·35
	12–18	is	0·35
	18–24	is	0·64.

There is thus a slight excess for stars usually observed about November as compared with those observed about April; but the correspondence with annual seasons is not very close.

In the Introduction to the Cape Catalogue, p. xiii, Mr. Stone, in comparing the Catalogue with the *Nautical Almanac* for 1880, says :—

" Next, in order to test whether there is any large outstanding correction depending upon the meteorological elements, I shall give the corrections required by the *N. A.* North Polar Distances for groups of six hours of Right Ascension.

Corrections to N. A. N.P.D.

0^h–6^h	6^h–12^h	12^h–18^h	18^h–24^h
$-0''\cdot55$	$-0''\cdot42$	$+0''\cdot08$	$-0''\cdot25$.

" . . . . It appears that the complete reversion of the seasons at the northern and southern observatories is not quite accurately allowed for in the refraction tables.

" The observations from 0^h to 6^h R.A. were made during the dry season at the Cape, and the tabular refractions appear relatively too great; whilst observations from 12^h to 18^h were made during the wet seasons at the Cape, and the tabular refractions appear relatively too small."

The *N. A.* places for 1880·0 are based on the Greenwich observations about 1860, and it is of interest to examine why the above corrections differ from those deduced by a direct comparison of the Cape and Greenwich Catalogues for 1880. On comparing the Greenwich Ten-Year Catalogue with the *Nautical Almanac* for 1880, Mr. Thackeray found (*Monthly Notices*, vol. li. p. 397) the following systematic differences between them :—

Excess of N.P.D. in Ten-Year Catalogue over N. A. 1880.

0^h–6^h	6^h–12^h	12^h–18^h	18^h–24^h
$-''\cdot19$	$+''\cdot10$	$+''\cdot39$	$+''\cdot17$.

Mr. Thackeray suggested that these differences might be due to the proper motions adopted by the *Nautical Almanac.*

To examine this point the proper motions adopted in the two Seven-Year Catalogues, on which the *N. A.* (1880) places depend, were compared with the proper motions deduced by Auwers from his reduction of Bradley's observations, which are now in use. The results are as follows :—

Excess of Proper Motion in N.P.D. as found by Main and Stone for N. A. Stars over Proper Motion found by Auwers.

Table II.

h h	"	h h	"	h h	"	h h	"
0–1	+·013	6–7	+·023	12–13	+·020	18–19	+·018
1–2	+·010	7–8	+·019	13–14	+·012	19–20	−·003
2–3	+·025	8–9	+·003	14–15	−·017	20–21	+·001
3–4	+·024	9–10	+·016	15–16	−·008	21–22	+·012
4–5	+·003	10–11	+·024	16–17	−·011	22–23	+·003
5–6	+·018	11–12	+·017	17–18	−·017	23– 0	+·016
0–6	+·016	6–12	+·017	12–18	−·004	18–24	+·008

Thus, since these stars have been brought up nearly twenty years (for most of them are taken from the 1860 Catalogue—see below), if we accept Auwers's proper motions as correct we must apply to the places in the *Nautical Almanac* for 1880 the corrections

0^h–6^h	6^h–12^h	12^h–18^h	18^h–24^h
−″·32	−″·34	+″·06	−″·16

and we shall then find for the differences between the Ten-Year Catalogue and the *Nautical Almanac* 1880,

Excess of N.P.D.s in Ten-Year Catalogue over N. A. 1880

0^h–6^h	6^h–12^h	12^h–18^h	18^h–0^h
+″·13	+″·44	+″·33	+″·34

and for the differences between Cape 1880 and *Nautical Almanac* 1880,

Excess of N. A. 1880 *over Cape* 1880

+″·23	+″·08	−″·02	+″·09.

Both these sets of residuals are more accordant; and the second set, together

with the more direct comparison between the Greenwich Ten-Year Catalogue and the Cape (1880) Catalogue previously given, viz.,

$+''\cdot46 \qquad +''\cdot35 \qquad +''\cdot35 \qquad +''\cdot64$

suggest that the correction for meteorological elements is much more satisfactory than the material at Mr. STONE's disposal led him to think.

The discussion of the outstanding constant difference of about $0''\cdot3$ or $0''\cdot4$ between the two Catalogues will be taken, more appropriately, later.

Meanwhile it may be remarked that we have here a testimony to the value of AUWERS's re-reduction of BRADLEY's observations, on which his proper motions are based ; for these proper motions secure an accordance between the Greenwich observations of 1860 and 1880 which the old proper motions would not allow of. This is, however, incidental, and does not concern the present comparison of Catalogues.

As regards the Right Ascensions, it is to be remarked that those of the Cape Catalogue depend upon the Greenwich clock-star lists for 1871–79, and those of the Greenwich Catalogue on the lists for 1877–86. These lists for 1871–77 are based on the R.A.s of the Second Seven-Year Catalogue (1864) ; but for 1878–86 on the standard R.A.s of the Nine-Year Catalogue (1872). A comparison between these R.A.s is printed in the Introduction to the Nine-Year Catalogue.

Thus observations at the Cape in the years 1878 and 1879 (to April 30), = 1·3 year, depend on the 1872 standard places ; and for 7 years on the 1864 Catalogue. So that if the stars were uniformly distributed throughout the 8·3 years we should have 7/8·3 = ·84 of the correction to 1864 Catalogue applicable to the Cape Catalogue, to reduce the R.A.s to the system of the 1872 standard R.A.s.

But there is a considerable departure from uniform distribution. The observations for the Cape Catalogue were made in zones, generally of 10°, as follows :—

N.P.D.	Observed in the Year	
175°–180°	1871	Special Catalogue Prepared.
165–175	1872 and 1873	Lacaille stars chiefly.
155–165	1874	" "
145–155	1875	" "
135–145	1876	Lacaille's and Brisbane's stars.
125–135	1877	" " "
115–125	1878	Lacaille and General Revision.
Miscellaneous	1879 April 30.	General Revision.

For small stars, therefore, the observations in the zones north of 125° (which alone are under consideration) are confined to the years 1878 and 1879, when the 1872 standard places were in use; but Greenwich clock-stars and fundamental stars were observed in the whole 8·4 years. On adding together the weights of all stars in each hour of R.A. for which the mean epoch of observation was later than 1878·0, and dividing by the total weight for that hour, the following ratios were found :—

Table III.

R.A.	Ratio.	R.A.	Ratio.	R.A.	Ratio.	R.A.	Ratio.
h h		h h		h h		h h	
0–1	·48	6–7	·54	12–13	·26	18–19	·47
1–2	·43	7–8	·59	13–14	·46	19–20	·39
2–3	·42	8–9	·54	14–15	·44	20–21	·39
3–4	·57	9–10	·38	15–16	·44	21–22	·39
4–5	·50	10–11	·42	16–17	·60	22–23	·32
5–6	·49	11–12	·53	17–18	·45	23–24	·37
Mean	·48	Mean	·50	Mean	·44	Mean	·39

There is not sufficient variation in these numbers to make it advisable to treat each hour separately, and it is assumed that the small stars observed in the years 1878 and 1879 at the Cape form ·45 of those available for comparison with Greenwich in R.A. The remaining stars are clock-stars and other fundamental equatorial stars, the observation of which may be considered to have been uniformly distributed throughout the period 1871·0–1879·3, and thus 1·3/8·3, or ·16 of these also were made in the years 1878 and 1879, when the places of the 1872 Catalogue were used for clock-stars. Hence, altogether ·45 + ·16 × ·55 = ·54 of the Cape R.A.s depend upon the 1872 standard places; and the remaining ·46 on the places of the 1864 Catalogue. Again, the Greenwich observations in 1877, or ·10 of those used for the Greenwich Catalogue, also depend on the 1864 places. Hence we must apply to the quantities G—C the fraction ·46 − ·10 = ·36 of the corrections to the 1864 Catalogue; and this fraction of the corrections, diminished by $0^{s}{\cdot}015$, the constant difference between the Catalogues, is given in column 3 and applied in column 4 of Table IV.

TABLE IV.

Limits of R.A.	G—C.	Corr.	G—C Corrected.	Limits of R.A.	G—C.	Corr.	G—C Corrected.
h h	s	s	s	h h	s	s	s
0–1	+·030	−·023	+·007	12–13	+·012	−·011	+·001
1–2	+·008	−·018	−·010	13–14	−·007	−·018	−·025
2–3	+·020	−·012	+·008	14–15	−·001	−·010	−·011
3–4	+·018	−·015	+·003	15–16	+·001	−·015	−·014
4–5	−·005	−·013	−·018	16–17	+·010	−·012	−·002
5–6	−·003	−·009	−·012	17–18	+·030	−·014	+·016
6–7	+·027	−·012	+·015	18–19	+·031	−·018	+·013
7–8	+·011	−·002	+·009	19–20	+·022	−·023	−·001
8–9	+·005	−·010	−·005	20–21	+·040	−·021	+·019
9–10	−·001	−·011	−·012	21–22	+·032	−·022	+·010
10–11	+·008	−·015	−·007	22–23	+·029	−·023	+·006
11–12	+·012	−·014	−·002	23–24	+·021	−·021	·000

The quantities in the finally corrected columns may be "smoothed" by taking means of every three, and means of three again. The results are then :—

TABLE V.

h h	s	h h	s	h h	s	h h	s
0–1	+·002	6–7	+·002	12–13	−·008	18–19	+·009
1–2	+·001	7–8	+·002	13–14	−·013	19–20	+·009
2–3	·000	8–9	−·002	14–15	−·013	20–21	+·010
3–4	−·004	9–10	−·006	15–16	−·009	21–22	+·009
4–5	−·005	10–11	−·006	16–17	·000	22–23	+·007
5–6	−·003	11–12	−·006	17–18	+·006	23–24	+·004
Means 0–6	·000	6–12	−·003	12–18	−·006	18–24	+·008

There is thus some systematic difference, especially from 9^h–23^h. In the Introduction to the Cape Catalogue Mr. STONE gives a comparison of the Right Ascensions with those of the *Nautical Almanac* for 1880. He finds for the quantity *N. A.*—Cape :—

From 0^h–6^h	6^h–12^h	12^h–18^h	18^h–0^h
$-^s{\cdot}001$	$+^s{\cdot}005$	$+^s{\cdot}018$	$-^s{\cdot}010$.

These are again at variance with the quantities found above for G—C, which we should expect to resemble them, considering that the *N. A.* places are based on Greenwich observations. The difference between the 3rd and 4th quarters is in the one case $+^{s}\cdot028$ and in the other $-^{s}\cdot014$. But we have not yet corrected the quantity *N. A.*—Cape in a similar manner to that in which G—C was corrected.

The places of the *Nautical Almanac* for 1880 are brought up from the Greenwich Seven-Year Catalogues for 1860 and 1864. Dr. Downing kindly informs me that in effect the additional stars introduced in the *Nautical Almanac* for 1880 (of which we are concerned with 45) were brought up from the 1864 Catalogue, and the remainder from the 1860 Catalogue, as in previous years. On separating the two sets we find—instead of Mr. Stone's combined results—

From	0^h–6^h	6^h–12^h	12^h–18^h	18^h–24^h
	s	s	s	s
Old stars	$-\cdot001_{31}$	$+\cdot016_{26}$	$+\cdot020_{25}$	$-\cdot004_{29}$
Additional stars	$-\cdot002_{10}$	$-\cdot013_{14}$	$\cdot000_{11}$	$-\cdot027_{10}$

where the suffixes indicate the number of stars in the group.

Now the corrections to the First and Second Seven-Year Catalogues to reduce them to the 1872 standard places are tabulated on p. 8 of the Introduction to Nine-Year Catalogue, and we have :—

From	0^h–6^h	6^h–12^h	12^h–18^h	18^h–0^h
	s	s	s	s
Corr. to First Seven-Year	$+\cdot006$	$-\cdot014$	$-\cdot004$	$+\cdot033$
Corr. to Second Seven-Year	$+\cdot012$	$+\cdot001$	$+\cdot008$	$+\cdot030$

these quantities being applicable with the same sign to *N. A.*—Cape. We must also apply $\frac{7}{8\cdot3} = \cdot84$ of the second row *with reversed sign* to the quantity *N. A.*—Cape, on account of the fact that the Cape observations of fundamental stars were based for seven years on the Second Seven-Year Catalogue, and for 1·3 year on the standard places. Hence we have for the corrected quantity, *N. A.*—Cape, the following values :—

	0^h–6^h	6^h–12^h	12^h–18^h	18^h–0^h
	s	s	s	s
From stars brought up from 1860	$-\cdot005_{31}$	$+\cdot001_{26}$	$+\cdot009_{25}$	$+\cdot004_{29}$
" " 1864	$\cdot000_{10}$	$-\cdot013_{14}$	$+\cdot001_{11}$	$-\cdot022_{10}$
Weighted Mean	$-\cdot004$	$-\cdot004$	$+\cdot007$	$-\cdot003$

Comparing these with the quantities for G—C, viz.,

$^s\cdot000$ $-^s\cdot003$ $-^s\cdot006$ $+^s\cdot008$

the difference between the 3rd and 4th quadrants still exists, but is considerably reduced. We have still to examine the proper motions in R.A. in a similar manner to those in N.P.D.

Forming the differences between those found for *N. A.* stars by MAIN and STONE and those found by AUWERS, we find for the mean excess of AUWERS's proper motions:

TABLE VI.

R.A. h h	s	h h	s	h h	s	h h	s
0–1	+·0007	6–7	—·0010	12–13	—·0010	18–19	+·0010
1–2	·0000	7–8	—·0004	13–14	—·0008	19–20	—·0002
2–3	+·0007	8–9	+·0003	14–15	—·0012	20–21	+·0006
3–4	—·0004	9–10	+·0011	15–16	—·0008	21–22	·0000
4–5	+·0001	10–11	+·0001	16–17	—·0005	22–23	+·0013
5–6	—·0012	11–12	—·0008	17–18	+·0006	23– 0	—·0004
0–6	·0000	6–12	—·0001	12–18	—·0006	18– 0	+·0004

Thus if AUWERS's proper motions had been used to bring up the *N. A.* places for 1880 instead of those of MAIN and STONE, we should have had for the quantities *N. A.*—Cape instead of

0^h–6^h	6^h–12^h	12^h–18^h	18^h–0^h
$-^s\cdot004$	$-^s\cdot004$	$+^s\cdot007$	$-^s\cdot003$

the values

$-^s\cdot004$ $-^s\cdot006$ $-^s\cdot005$ $+^s\cdot005$

and these compare remarkably well with the quantities deduced from the direct comparison of the Catalogues, viz.,

$^s\cdot000$ $-^s\cdot003$ $-^s\cdot006$ $+^s\cdot008$.

We may take it, then, that these last two lines represent the real systematic differences between the Cape and Greenwich observations, and, incidentally, that AUWERS's proper motions are satisfactorily free from systematic error.

In *Monthly Notices*, vol. li. pp. 306 *et seq.*, Dr. DOWNING gives an indirect comparison of the two Catalogues here considered—the Greenwich Ten-Year (1880) and the Cape (1880) Catalogue—deduced from the comparison of each with the Second Melbourne Catalogue (1880). The arrangement of results

in both elements for each hour of R.A. is given on p. 309. The figures do not at all agree with those given above, as will be obvious from the following table :—

TABLE VII.

Greenwich—Cape.

	R.A.			N.P.D.	
	Direct Comparison.		Indirect (Downing).	Direct Comparison.	Indirect (Downing).
	Uncorrected.	Corrected.			
h h	s	s	s	"	"
0–1	+·030	+·004	−·011	+0·44	−0·13
1–2	+·008	+·004	−·005	+0·47	−0·10
2–3	+·020	+·002	+·013	+0·63	+0·04
3–4	+·018	−·003	+·020	+0·33	+0·08
4–5	−·005	−·006	+·019	+0·47	−0·02
5–6	−·003	−·003	−·002	+0·44	−0·22
6–7	+·027	+·002	−·011	+0·22	−0·25
7–8	+·011	+·002	+·001	+0·32	−0·12
8–9	+·005	−·002	+·004	+0·36	−0·15
9–10	−·001	−·007	−·012	+0·42	−0·09
10–11	+·008	−·006	−·025	+0·70	+0·10
11–12	+·012	−·007	−·042	+0·21	+0·12
12–13	+·012	−·008	−·042	+0·33	+0·18
13–14	−·007	−·013	−·034	+0·41	+0·28
14–15	−·001	−·013	−·039	+0·40	+0·28
15–16	+·001	−·009	−·038	+0·16	+0·15
16–17	+·010	·000	−·021	+0·36	+0·11
17–18	+·030	+·006	−·005	+0·46	+0·21
18–19	+·031	+·010	+·008	+0·76	+0·20
19–20	+·022	+·010	+·013	+0·74	+0·15
20–21	+·040	+·010	+·026	+0·53	+0·21
21–22	+·032	+·008	+·045	+0·86	+0·33
22–23	+·029	+·007	+·043	+0·51	+0·33
23–24	+·021	+·004	+·005	+0·49	+0·09
Mean	+·015	·000	−·004	+0·45	+0·07

The cause of this discrepancy is simple: the quantities Greenwich—Melbourne and Greenwich—Cape depend on stars lying in the equatorial belt, while Melbourne—Cape depends on all southern stars to the South Pole. Hence the first and third cannot be added together to give the second unless all three Catalogues are quite free from systematic error in N.P.D., which is by no means the case either for R.A. or N.P.D. It would therefore appear difficult to assign any real meaning to the indirect comparison given in Dr. DOWNING'S paper.

(2) *The Comparison in order of N.P.D.*

The stars were collected in groups of fifty stars, and the weighted mean taken for each group. The results are as follows:—

TABLE VIII.

Mean N.P.D. of Group.	Diff. of R.A. G—C. × sin N.P.D.	Weight.	Diff. of N.P.D. G—C.	Weight.
° ′	s		″	
55 44	+0·016	346	+0·11	230
71 57	+ ·002	559	+0·43	384
81 30	+ ·006	471	+0·69	475
86 55	− ·003	400	+0·25	452
92 2	− ·008	320	+0·06	437
96 28	+ ·006	274	+0·31	393
99 55	+ ·010	348	+0·45	466
103 40	+ ·006	269	+0·45	348
107 32	+ ·020	329	+0·39	422
112 22	+ ·028	273	+0·61	306
114 20	+ ·024	256	+0·43	266
115 45	+ ·046	271	+0·57	268
117 32	+ ·027	261	+0·81	217
119 17	+ ·047	271	+0·85	210
122 9	+ ·028	260	+0·96	147
125 27	+ ·064	58	+2·97	16½

With regard to the R.A.s, the increasing positive value of G—C below 100° N.P.D. is found by Dr. DOWNING (whose comparison of the Catalogues

above referred to is, of course, perfectly valid for the arrangement in N.P.D.) to be also a feature of the comparison, Greenwich—Melbourne. It is possible that it is due to the well-known tendency to observe the transits of faint stars *late*, for the atmospheric absorption decreases the brightness of stars below 110° N.P.D. at Greenwich as compared with those above this limit; and the reverse happens at the Cape; but in this case the quantity $+^{s}\cdot016$ at 55° 44′ is of the wrong sign. This may very well be accidental, for it is not reproduced in Dr. DOWNING's comparison, and, moreover, the observation of northern stars at the Cape was not made a matter of importance.

But the whole of the discordances may be due to instrumental error. The instruments of Greenwich and the Cape are not reversible, and the information obtainable as to lateral flexure is not extensive. As regards the Greenwich Transit Circle, there is given every year in the Introduction to the Greenwich Observations a table of Corrections to Adopted Level Errors, deduced from reflection observations of stars in R.A., which corrections may be considered due to pivot errors or lateral flexure. The corrections indicated are, however, small, and the observations are scarcely numerous enough to determine such small quantities with accuracy. In *Monthly Notices*, vol. lii., Mr. TURNER shows that, generally speaking, they may be partly attributed to a small systematic error in adopted collimation, owing to the change in the error introduced by observing the collimators through the central cube.

In the same paper, however, it is shown that observations of circumpolar stars show systematic errors far in excess of those attributable to this error of collimation, which must be due to some other cause, but that this cause has affected different years quite differently. This must be remembered in any discussion of circumpolar observations, such as that in the Introduction to the Ten-Year Catalogue, where a table is given of the excess of R.A. above Pole × sin N.P.D. for every ten stars in order of N.P.D. The complete discussion of systematic errors in R.A. would, however, take too much space here, and must be dealt with in another paper.

Finally we come to the comparison of N.P.D.s arranged in order of N.P.D., which raises more important questions than any of the other three: the co-latitudes of both observatories, refractions used, and corrections for flexure and R—D being all involved. It is first to be remarked that while BESSEL's "Refractions of the Tabulæ Regiomontanæ" were used at Greenwich

as far as Z.D. 85°, at the Cape these refractions were diminished in the proportion of 0·9988 to 1, owing originally to the omission of an index error (0°·55) of the thermometer used, but finally to the fact that these diminished refractions seemed to Mr. Stone to suit the observations sufficiently well. It has seemed to me better, at any rate in the first instance, to reduce both refractions to the same system, and I have accordingly applied corrections to the Cape observations to reduce them to the refractions of the "Tabulæ" unaltered, including an alteration of the Cape co-latitude, as determined from observations of circumpolar stars, by the quantity + 0″·09.

The quantity G—C is thus corrected in the sixth column of Table XII.; other columns are sufficiently explained by the headings. The seventh column (the sum of tan Z.D. for Greenwich and tan Z.D. for the Cape) is the factor by which any correction to the mean refraction must be multiplied in order to be applicable to the quantity G—C on the above hypothesis of identical refractions at the two stations.

There is also required a small correction to the adopted Greenwich co-latitude if we deduce it strictly from observations made in the years 1877–86. In the Introduction to the Ten-Year Catalogue the co-latitude deduced from stars is found to be 38° 31′ 21″·935, the seconds of the adopted value being 21″·90.

Finally, the first group of fifty stars is somewhat anomalous, for we should expect a general symmetry of the residuals about the mid point between Greenwich and the Cape (N.P.D. 81°) if the outstanding differences are due to refraction. The quantity G—C, though apparently a difference, is really a *sum* of zenith distances; and an error in refractions which would give the residuals at N.P.D. 120° a large positive value because of their great zenith distance at Greenwich, should also give the residuals at N.P.D. 40° a large positive value because of their great zenith distance at the Cape. The small value +0″·11 of G—C for the first group in Table VIII., which is the only group for which the zenith distance at the Cape is considerable, is somewhat puzzling, unless we consider it due to accidental error. On a more detailed examination this would appear to be probable. If the fifty stars are divided into five groups of ten we find—

Table IX.

Mean N.P.D.	Z.D. at Greenwich.	Z.D. at Cape.	Weight.	G—C (Corrected).
° ′ 42 35	° ′ 4 4	° ′ 81 21	19	″ +0·33
49 35	11 4	74 21	41	−0·45
59 31	21 0	64 25	117	+0·61
62 5	23 34	61 51	84	+0·33
64 56	26 25	59 0	85	+0·90

The large negative residual in the second group led to an examination of the individual observations, and it was found that practically all the observations of the first twenty stars were made in the years 1870–72, during which there was an anomalous flexure. Mr. Stone's remarks on this point will be found in the Introduction to the Cape Results for 1874, p. xiv; and here it need only be mentioned that "there existed a systematic discordance of rather more than a second of arc between the zenith-point readings determined with the reflecting eyepiece and from direct and reflection observations of stars"; that Mr. Stone was led to apply a correction of the form

$$a \sin z + b \cos z + c \sin 3z$$

to the N.P.D.s of these three years, and considered the result satisfactory; and that on "readjusting the instrument generally" in 1873 the anomaly disappeared. My own examination of the results has not satisfied me that the correction of the N.P.D.s in 1870–72 is complete, and I consider that we shall lose nothing by excluding the first twenty stars from the present comparison; so that in the following table the first group now consists of only thirty stars.

TABLE X.

Group.	Mean N.P.D.	Z.D. at Greenwich.	Z.D. at Cape.	Weight.	G—C Corrected.	Sum of tan Z.Ds.	R.
1	° ′ 62 10	° ′ 23 39	° ′ 61 46	130	″ +0·74	2·299	″ +0·21
2	71 57	33 26	51 59	384	+0·63	1·939	+0·14
3	81 30	42 59	42 26	475	+0·87	1·846	+0·39
4	86 55	48 24	37 1	452	+0·42	1·880	−0·07
5	92 2	53 31	31 54	437	+0·22	1·974	−0·28
6	96 28	57 57	27 28	393	+0·47	2·117	−0·04
7	99 55	61 24	24 1	466	+0·60	2·280	+0·07
8	103 40	65 9	20 16	348	+0·60	2·528	+0·05
9	107 32	69 1	16 24	422	+0·53	2·901	−0·06
10	112 22	73 51	11 34	306	+0·74	3·658	+0·07
11	114 20	75 49	9 36	266	+0·56	4·126	−0·15
12	115 45	77 14	8 11	268	+0·70	4·558	−0·05
13	117 32	79 1	6 24	217	+0·94	5·265	+0·11
14	119 17	80 46	4 39	210	+0·98	6·233	+0·06
15	122 9	83 38	1 47	147	+1·09	8·993	−0·11
16	125 27	86 56	−1 31	$16\frac{1}{2}$	+3·09	18·640	+0·93

Now if we neglect the systematic errors (flexure, &c.) at the two observatories, or consider them well determined, the positive differences G—C indicate a diminution in the coefficient of refraction. To determine its amount we must first notice that such a diminution would alter the co-latitudes of both observatories, which depend on observations of circumpolar stars. A diminution of 0″·10 in the coefficient (or expressed as a ratio a diminution of ·9983 to 1) would diminish the Greenwich co-latitude by 0″·12, and the Cape (South) co-latitude by 0″·18; and if ζ be the sum of the tangents of Z.D. at Greenwich and the Cape (given in the seventh column of Table XII.), the total diminution of G—C is

$$0''\cdot30+\zeta\times0''\cdot10=0''\cdot10(\zeta+3).$$

Let x be the proper diminution of refraction to satisfy the observations. Then for the first eleven groups of the above table, down to 76° Z.D. at

Greenwich, the mean value of ζ is 2·504, and the mean value of G—C is 0″·58 ; so that

$$x(\zeta+3)=5\cdot504x=0''\cdot58,$$

or

$$x=0''\cdot106.$$

From the next three groups (Z.D. 76° to 81°) we get similarly

$$x=0''\cdot10,$$

from group 15

$$x=0''\cdot09,$$

and from group 16

$$x=0''\cdot14.$$

The significance of these last three results is doubtful, for it is possible that below 75° the refraction can no longer be considered to vary simply as tangent Z.D.

The quantities G—C corrected for a diminution of 0″·10 in the constant of refraction are given in the column R. of the above table.

It remains to be seen how far this alteration of refractions would suit other observations—circumpolar observations, &c. On examining the circumpolar observations at the Cape, given in the Introduction to the Cape Catalogue, it is seen that a much larger diminution of refractions would suit them, and therefore that here suggested is in the right direction. The change made by an alteration of 0″·10 is shown in the fourth column below.

Table XI.

Group.	N.P.D.	Excess of N.P.D. above Pole.	Corrected for refraction.
	° °	″	″
1	173 to 180	+0·02	+0·32
2	168 to 172	+0·14	+0·47
3	163 to 167	−0·32	+0·06
4	158 to 162	−0·70	−0·23
5	152 to 157	−1·10	−0·37

The Greenwich circumpolar observations are reproduced below from the Introduction to the Ten-Year Catalogue, with the corrections for diminished refractions in the fifth column :—

TABLE XII.

Group.	Mean N.P.D.	Weight.	Mean Excess of N.P.D. above Pole.	Corrected for refraction.
	° ′		″	″
1	5 50	633	−0·15	+0·01
2	10 47	528	−0·12	+0·05
3	15 7	560	+0·22	+0·40
4	18 27	520	+0·12	+0·31
5	21 17	445	+0·25	+0·45
6	23 32	467	+0·15	+0·36
7	25 13	457	+0·10	+0·33
8	27 9	417	−0·24	0·00
9	28 49	418	−0·20	+0·06
10	30 44	334	−0·66	−0·39
11	33 36	276	−0·37	−0·05
12	36 36	189	−0·51	−0·13
13	40 12	123	−0·29	+0·21
14	41 54	27	−0·45	+0·14
15	42 48	14	−0·75	−0·12
16	43 32	19	−1·17	−0·46
17	44 16	27	−0·76	+0·03
18	45 38	15	−2·28	−1·38
19	47 38	7	−4·94	−3·44

Here, again, the accordance is undoubtedly better with diminished refractions. The co-latitude is now 38° 31′ 21″·81.

Circumpolar observations at Pulkowa led to the adoption of a diminution of the coefficient of refraction by 0″·16.* But it has been already remarked by Mr. CHRISTIE, in his paper "On the Systematic Errors of the Greenwich North Polar Distances" (*Mem. R.A.S.*, vol. xlv. p. 4), that the method of circumpolar stars for determining refraction "is of little value, for the differential effect of a correction to the refraction on stars at different distances from the pole, which is all that we can observe, is so small as far as Z.D. 75° that the uncertainty of the flexure correction is sufficient to mask it; whilst below 75° the law of refraction is itself somewhat uncertain, and the

* *Tabulæ Refractionum in usum Speculæ Pulcovensis congestæ.* Petropoli, 1870.

observations are comparatively few and subject to large probable errors. Hence for the determination of the coefficient of refraction, we are virtually dependent on observations of southern stars, the discussion being complicated by the circumstance that the co-latitudes of both the northern and southern observatories enter into it. But the effects of refraction are here all additive, whereas in the case of circumpolar stars they are differential."

When, however, we turn to the observations of the sun made at Greenwich, the correction to co-latitude will be in the other direction. It has been shown in several previous papers on the Greenwich North Polar Distances that the general effect of an alteration in refractions is to alter the co-latitude deduced from solar observations by *twice* the alteration in that deduced from stars and *in the contrary direction.* Now it has been shown by Mr. THACKERAY (*Mem. R.A.S.*, vol. xlix.) that the co-latitude derived from observations of the sun during the years 1877–86 (the years in which observations for the Ten-Year Catalogue were made) is

$$S_1 = 38^\circ\ 31'\ 21''\cdot 68$$

if the ordinary exterior thermometer is used in computing refraction,

$$S_2 = 38^\circ\ 31'\ 21''\cdot 91$$

if the Front Court, or Meteorological Standard thermometer is used. The result obtained by Mr. THACKERAY from stars is

$$38^\circ\ 31'\ 21''\cdot 92,$$

sensibly agreeing with the result

$$C = 38^\circ\ 31'\ 21''\cdot 935$$

quoted above from the Introduction to the Ten-Year Catalogue. These quantities will thus become, if we diminish the refractions,

S_1	S_2	C
21″·92	22″·16	21″·81.

The evidence thus tends to show that the suggested diminution is too large, and can only be accepted if we regard the reading of the ordinary exterior thermometer, which is sheltered by the north wall of the Transit Circle Room, as more nearly correct than that of a thermometer exposed under standard conditions. It must, however, be remembered that the accidental error of solar observations is large.

In assuming the residuals G—C to be due to error in refraction, we have neglected the systematic instrumental errors in N.P.D. A complete discussion of this lies, perhaps, outside the scope of the present paper; but one or two remarks may be useful for reference. The chief correction to

zenith distance observations is that for flexure or R—D, of the form C sin Z.D. At Greenwich such a correction has been applied to the observations under discussion, being in this case called an R—D correction. The coefficient C was determined by reflection observations of stars to be $+0''\cdot61$; although observations of horizontal flexure by means of the collimators gave a coefficient sensibly zero. It would thus appear that this correction may be too large, and that more weight should be attached to the indications of the collimators. If we assume that it is too large, we must ascribe part of the differences G—C to this erroneous correction. As an illustration, let us examine the effect of decreasing the coefficient C to one-half its value, which corresponds to considering the horizontal flexure observations and the R—D observations equally good, or rather equally liable to error.

We must first correct the co-latitude of Greenwich. The observations of circumpolar stars will be corrected as below :—

TABLE XIII.

Mean N.P.D. of Group.	Weight.	Original Excess of N.P.D. above Pole.	Corrected to ½(R—D).
° ′		″	″
5 50	633	−0·15	+0·23
10 47	528	−0·12	+0·25
15 7	560	+0·22	+0·59
18 27	520	+0·12	+0·48
21 17	445	+0·25	+0·60
23 22	467	+0·15	+0·50
25 13	457	+0·10	+0·44
27 9	417	−0·24	+0·10
28 49	418	−0·20	+0·14
30 44	334	−0·66	−0·34
33 36	276	−0·37	−0·06
36 36	189	−0·51	−0·20
40 12	123	−0·29	0·00
	Weighted Mean	−0·07	+0·28

The co-latitude is now $38° 31' 21''\cdot76$; that from solar observations will be altered about $0''\cdot25$, *increasing* instead of *decreasing*, and we shall have :—

$$S_1 = 38° \; 31' \; 21''\cdot93 \text{ (ordinary exterior thermometer)}$$
$$S_2 = 38 \; 31 \; 22\cdot16 \text{ (standard exterior thermometer)}$$

We have thus not improved the accordance of the circumpolar observations, nor of the stellar and solar co-latitudes; but the quantities G—C are altered as below :—

Table XIV.

Group.	G—C.	Corrected.	Group.	G—C.	Corrected.
1	+0″·74	+0″·50	9	+0″·53	+0″·10
2	+0·63	+0·32	10	+0·74	+0·30
3	+0·87	+0·52	11	+0·56	+0·12
4	+0·42	+0·05	12	+0·70	+0·26
5	+0·22	−0·17	13	+0·94	+0·50
6	+0·47	+0·07	14	+0·98	+0·54
7	+0·60	+0·19	15	+1·09	+0·65
8	+0·60	+0·18	16	+3·09	+2·65

The weighted mean of the first fourteen groups is now +0″·24, so that we must either still further reduce the R—D correction or diminish the refractions; in either case emphasising the discordances in co-latitude observations noted above. A diminution of the R—D correction at Greenwich (or at the Cape) is in fact nearly equivalent to a diminution of the refractions, with one important exception, viz., *that the discordance in observations of circumpolar stars is magnified and not diminished.* Without independent evidence, therefore, it is difficult to choose between the two methods of adjusting the residuals. We may diminish either (1) the refraction, or (2) the R—D correction, or (3) both conjointly, or (4) increase one and diminish the other. Cases (1) and (2) have been already considered, and case (3) shares with them the disadvantage of upsetting the accordance between the solar and stellar co-latitudes. But in case (4) we can adjust the relative coefficients of increase and diminution so as to avoid this. We have seen that a diminution of the coefficient of refraction by 0″·10 alters the arc EP from the equator (solar observations) to the pole (stellar observations) by 0″·36; and a diminution of the coefficient of R—D by 0″·30 alters this arc by 0″·39 in the same direction. Thus, if we alter the coefficient of refraction we must alter the coefficient of R—D by twice or three times as much in the opposite direction to keep the arc EP constant. But which coefficient shall be increased and which diminished? Without independent evidence we must

turn to the most striking difference between them, which was remarked above, viz., a *decrease* in the coefficient of refraction, or an *increase* in the coefficient of R—D, will improve the circumpolar observations, and *vice versâ*. Briefly, if we *decrease* the coefficient of refraction by 0″·13, and *increase* the coefficient of R—D by 0″·20, both changes will improve the circumpolar observations, the arc EP will not be much altered, and the residuals G—C will be fairly accounted for. The results of these changes are shown in the following tables. The seconds of co-latitude of Greenwich are now 21″·88 from stars, 21″·84 from solar observations with ordinary thermometer, and 22″·07 from solar observations with standard thermometer; the value 21″·90 being adopted below. The co-latitude of the Cape is altered by 0″·23.

TABLE XV.

Greenwich Circumpolar Observations.			Comparison of Greenwich and Cape.		
N.P.D.	Excess above Pole.	Excess Corrected as above.	N.P.D.	G—C from Table.	G—C Corrected as above.
° ′	″	″	° ′	″	″
5 50	−0·15	−0·19	62 10	+0·74	+0·29
10 47	−0·12	−0·15	71 57	+0·63	+0·26
15 7	+0·22	+0·21	81 30	+0·87	+0·54
18 27	+0·12	+0·13	86 55	+0·42	+0·10
21 17	+0·25	+0·28	92 2	+0·22	−0·11
23 22	+0·15	+0·20	96 28	+0·47	+0·13
25 13	+0·10	+0·17	99 55	+0·60	+0·25
27 9	−0·24	−0·15	103 40	+0·60	+0·22
28 49	−0·20	−0·08	107 32	+0·53	+0·11
30 44	−0·66	−0·51	112 22	+0·74	+0·23
33 36	−0·37	−0·16	114 20	+0·56	−0·01
36 36	−0·51	−0·21	115 45	+0·70	+0·07
40 12	−0·29	+0·17	117 32	+0·94	+0·22
41 54	−0·45	+0·13	119 17	+0·98	+0·14
42 48	−0·70	−0·09	122 9	+1·09	−0·1
43 32	−1·27	−0·43	125 27	+3·09	+0·64
44 16	−0·76	+0·08			
45 38	−2·28	−1·20			
47 38	−4·94	−3·20			

But there is no reason at present known why the adopted correction for R—D at Greenwich should be too small; rather the contrary, for, as remarked above, the horizontal collimator observations show a very small flexure.

If we turn to the Cape, published information about the R—D and flexure corrections is meagre. The years 1871–73 have already been referred to and dismissed from consideration in the present discussion. No correction for flexure was applied in the years 1874 and 1875, observations with the collimators showing that it was small. In the Introduction to the Cape Observations for 1876 occurs the following paragraph :—

"The astronomical flexure of the Transit Circle, as determined from observations of the opposite collimators, appeared to be insensible, and no correction for flexure has been applied to the circle observations during the year 1876 up to August 13. On 1876 August 14 it was found that the object-glass had been left exposed to a shower of rain, and that moisture had found its way between the lenses. The lenses were separated by me and carefully cleaned, and the instrument generally readjusted. The flexure was afterwards found from observations on September 2 and September 8 to be $-0''\cdot292$ sin Z.D. (South), and has remained sensibly of the same amount up to the present time."

The date of this Introduction is 1879 May 7, and no further annual results have been published by Mr. STONE, though he remarks: "The separate results for 1877, 1878, and 1879 (to April 30) have been prepared for press, and will be printed in England to avoid delay." We can thus only presume that the correction $-0''\cdot3$ sin Z.D. (South) was applied to the results for the remaining years including 1878 and 1879, with which we are chiefly concerned.

I have carefully examined the detailed observations at the Cape about 1876 August 13, and find that there is evidence of some change in the systematic zenith distance errors at about that time, whether due to meteorological causes, or to the same cause which produced an apparent change in flexure, it is not easy to say. It is much to be desired that more observations of flexure, or of stars by reflection, had been made in these later years; but the *published* information on such points is very meagre. The separate results for the years 1877–79, promised in the Introduction to the volume

for 1876, have never been published; and it has already been remarked that most of the observations on which the comparison of catalogues here under discussion depends were made in these years.

General Conclusions.

(1) The differences between the Greenwich and Cape Right Ascensions, when arranged in order of Right Ascension, are sensibly attributable (as they should be) to the differences in the places of fundamental stars used, the Cape observations depending partly on the Greenwich Seven-Year Catalogues. In comparing either series with the *Nautical Almanac* for 1880, it must be remembered that the places in this volume include twenty years' proper motions determined by Main and Stone, which Auwers's re-discussion of Bradley's observations has shown to be affected with systematic errors.

(2) When the Greenwich and Cape N.P.D.s are arranged in order of Right Ascension, the annual inequality, such as would arise from an erroneous temperature correction to refraction, is small. The temperature correction to refraction may therefore be regarded as fairly satisfactory. In comparing either series with the *Nautical Almanac* for 1880, the same remark applies as in the comparison of Right Ascensions, but with greater force.

(3) When the Right Ascensions of the two Catalogues are compared in order of N.P.D. it is apparent that the Greenwich Right Ascensions of low stars are larger than those of the Cape. This is possibly due to the reduction of light of a star by atmospheric absorption, coupled with the known tendency to record the transit of a faint star too late.

(4) When the N.P.D.s are compared in order of N.P.D., a positive difference is apparent which, if the systematic errors of the two transit circles be considered well determined, would indicate a diminution of the coefficient of refraction in the ratio of ·9970 to 1, but not further; and in this case we must assume an *increase* of the R—D correction at Greenwich, which independent evidence would not justify. This diminution of refraction would suit the circumpolar observations at both observatories, and is substantially the same as that obtained by circumpolar observations at Pulkowa; but it is much to be desired that the separate results of the Cape observations for 1878 should be published.

An Experiment with a $12\frac{1}{2}$-inch Refractor, whereby the Light lost through the Secondary Spectrum is separated out and rendered approximately measurable. (*With Plate.*) By H. DENNIS TAYLOR.

[Received and read, April 13, 1894.]

IN a former paper which I had the honour to read before you last November I showed theoretical reasons, founded upon the spectrometrically-observed refractive indices of crown and flint glasses, for supposing that a very serious amount of light must be lost for defining purposes in the case of large-sized objectives; or, in other words, only a portion of the light transmitted by the objective really contributes to the formation of the spurious disc or star image, while the other aberrant rays only form a useless halo of wasted light, which only fails to be more bright and conspicuous than it actually appears because of its diffusion over comparatively large areas of the focal plane. And I pointed out that if the laws of geometric optics applied strictly to the cone of rays condensing to and expanding from the star image at the focus, then the proportion of light actually contributing to the formation of the star disc in the case of a large refractor (say 2 feet aperture and 30 feet focal length) would be only a very small fraction of the light transmitted—that, in fact, anything like distinct vision would be impossible. But owing to the great discrepancy between deduction from the laws of geometric optics in this case and the actually observed state of things at the focus, caused, no doubt, by the operation of interference in a manner not yet worked out, the colour aberrations of much larger objectives are rendered innocuous in effect *compared with what they might be.* For owing to the remarkable manner in which the cone of rays tapers off into an approximately cylindrical

form for some distance on either side of the focus, the depth of focus (to borrow a term from photographic optics) is increased about fivefold, or the "focal layer" as defined in my previous paper is increased fivefold.

These focal phenomena very much complicate the problem of estimating the proportion of light transmitted which goes to the formation of, and contributes to, the brightness of the star disc. However, by means of a graphic method I arrived at certain approximate results. At the same time I had in my mind's eye an experiment by which I hoped to check or confirm the data arrived at by the theoretical method. The object of this experiment is to separate out the amount of light which, owing to the secondary colour aberrations, falls outside the limits of the spurious disc or star image, from the amount of light which actually contributes to the formation of the star disc. The theorem on which this experiment depends is tolerably simple. In the first place the image of a star formed by an ordinary refracting telescope is a spurious disc, formed by that light which falls within certain limits of accurate focus. Round this disc are an infinite series of circles of aberration, formed by those other colours which fall more or less within or beyond the true focus. The brightest aberrant colours form the smallest circles of aberration, of sizes comparable to the size of the spurious disc, while the less bright colours (approaching the two ends of the spectrum) form circles of aberration of relatively *enormous* size. In the case of a 2-foot o.-g. of 30 feet focal length, the circle of aberration for the red B ray is ·0166 inch diameter, or about 40 times the diameter of the spurious disc, which is ·0004. The G ($H\gamma$) ray forms a circle of aberration ·0666 inch in diameter, or 166 times the diameter of the spurious disc. Representing the spurious disc or star image by a circle $\frac{1}{20}$ of an inch diameter, as in fig. 8, then the circle of aberration for the B ray will be 2·1 inches diameter, and the same for the G ray will be no less than 8·3 inches in diameter.* In plate 5, fig. 8 I have filled in certain circles of aberration for rays of other colours, as indicated.†

Now let it be supposed that such a 2-foot o.-g. is focussed upon a distant

* I have left out of consideration the violet rays between G and H, as their luminous intensity is exceedingly small. Moreover, the circle of aberration for the H ray would fall entirely outside the limits of the diagram.

† To make this diagram approximate to the truth, I have deducted a constant (equal to four times the diameter of the spurious disc) from the diameter of the circles of aberration, as calculated by geometrical optics.

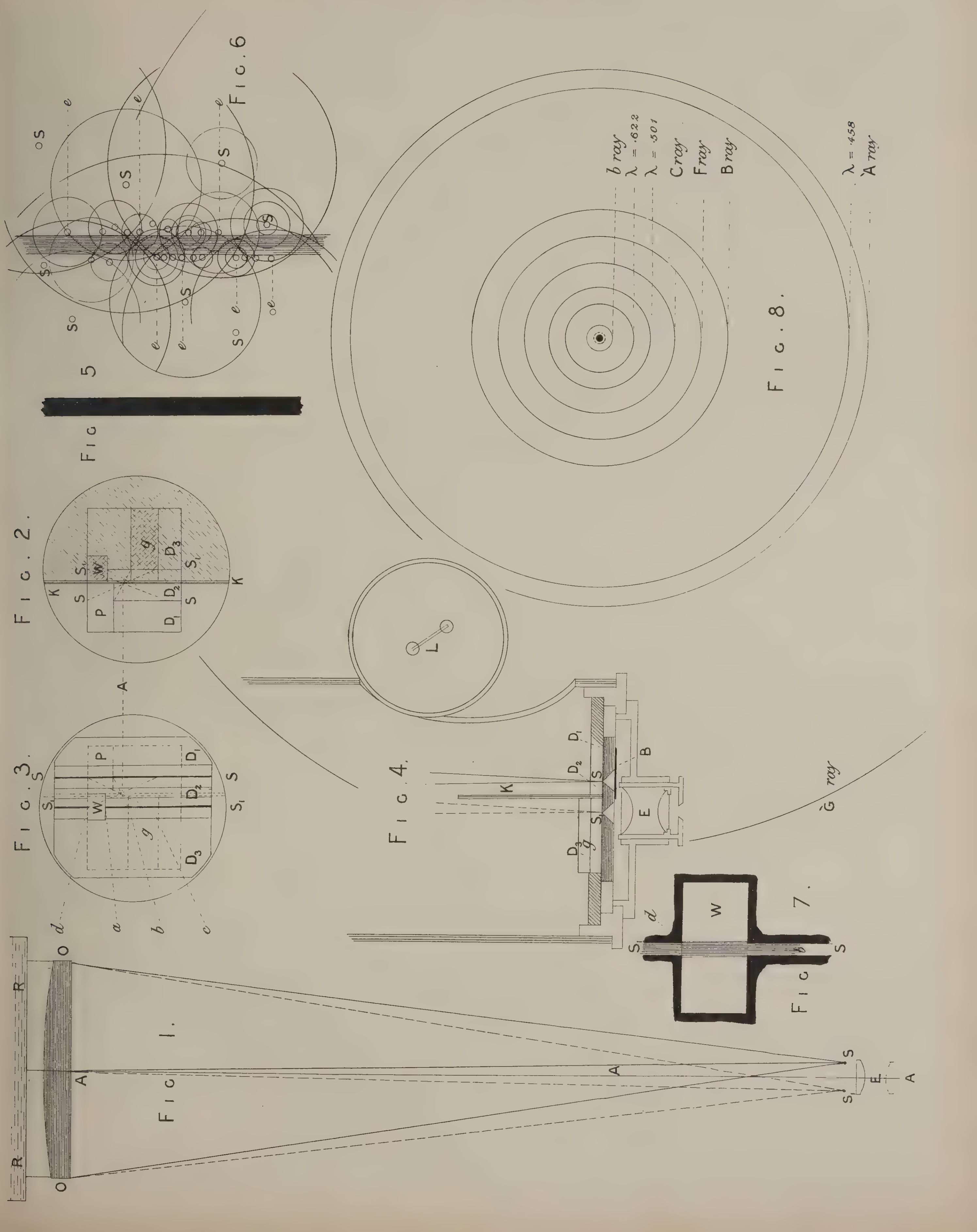


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5
Fig. 6
Fig. 7.
Fig. 8.
b ray
λ = .622
λ = .501
C ray
F ray
B ray
λ = .458
A ray
G ray

absolutely black line (fig. 5) drawn upon a uniformly white background, it being supposed that the angular width of the black line is about twice the angular diameter ($0''.4$) of the spurious disc. Fig. 6 will then represent the structure of the telescopic image of the black line.

In the first place, every point of either edge of the original black line is painted by the object-glass as a spurious disc *e*, *e*, *e*. In fact, the edges may be considered as formed by an infinite linear series of spurious discs, $e-e$, &c., each of which, be it remarked, is surrounded with its own series of circles of aberration, as indicated. Also the image of the continuous white surface is made up of an infinite series of spurious discs, each surrounded with its own series of circles of aberration. It is evident, therefore, since the radius of the largest circle of aberration (for the $\tilde{G}$ ray) is about $\frac{1}{30}$ of an inch, that all spurious discs forming the white surface which fall within $\frac{1}{30}$ of an inch from the black line will throw some portion of their aberrant light into the area occupied by the image of the black line. That is, the image of the black line cannot be truly black, but is really filled in by the light contributed by the infinite series of circles of aberration which overlap it. Supposing the area of white surface to be sufficiently large ($\frac{1}{4}$ inch square, or more), then we may consider the image of that white surface to be built up of two moieties or classes of light.

1st. That light which is refracted truly to focus, and forms a spurious disc for every point of the white surface. This is the light used strictly for defining purposes, and it forms the defined image of the black line.

2nd. That light which is *not* refracted to correct focus, but forms halos or circles of aberration around each point of the white surface. This light, wasted for defining purposes, yet paints an area of uniformly bright surface not appreciably differing in relative size from the true image of the white surface, but with a very blurred outline.

Now the image of the white surface, as we see it, is essentially composed of the above two elements superimposed on one another, and it scarcely needs explaining that the area of the image of the black line, being entirely unoccupied by light of the 1st class, leaves the light of the 2nd class, or the wasted light, to reveal itself.

In the white surface we have the *whole* light transmitted by the object-glass represented.

Within the area of the image of the black line, on the other hand, we have laid bare to our view a narrow section of that uniformly bright area of wasted light which really overlies the whole image of the surface.

Therefore, if we can measure the relative intensities of the light falling within the "black" line as compared with the surrounding white, then we shall obtain the ratio between the light which is wasted for defining purposes and the whole light transmitted by the objective.

Here it should be borne in mind that a considerable proportion of wasted light consists of light of those colours which are so *slightly* aberrant from true focus as to form halos or circles of aberration, of diameters equal to from $1\frac{1}{2}$ time to 3 times the diameter of the spurious disc. It is obvious, then, that if we require this moiety of wasted light (see small circles round *e*, *e*, *e*, &c., fig. 6) to contribute to the brightness of the more central parts of the image of the black line, then we must have the black line as narrow as possible, consistently with it presenting an appreciable width. Thus, in order to obtain the most accurate result, the black line should be very narrow indeed, say of a width equal to the diameter of the spurious disc. But unfortunately the narrower is the black line, the more hopelessly difficult does it become to *measure* the relative intensity of the wasted light which falls within it.

The wider the black line becomes the darker it grows down the centre, owing to the failure of the smallest circles of aberration to overlap it. Thus the most accurate *practical* measurement likely to be made of the relative brightness of the wasted light in the black line will be apt to underestimate the real proportion of wasted light, for the possibility of making such a measurement depends upon the image of the black line not being less in width than about $2\frac{1}{2}$ times the diameter of the spurious disc—at least, so I found in actual practice. The way in which the measurement was carried out was as follows :—

I took a very perfect objective (O — O, fig. 1) of 12·6 inches aperture and about 185 inches focal length (almost exactly fifteen times its aperture), and fitted it up in a horizontal tube in a dark passage, opposite a flat optically worked mirror R — R of 16″ aperture (but not silvered). The line A — A represents both the optic axis and a perpendicular to the mirror. S

represents the original black line on a white background, and S_1 represents the reflected image of the same formed after *two* passages through the object-glass. This method has great practical advantages over any other ; it does away with the necessity for viewing the original object through a great distance of unsteady air out of doors, which would also be likely to throw atmospheric haze over the image of the black line and vitiate the results ; it enables the observer to be in darkness and isolated from currents of disturbing air. Not only so, but there is the further great advantage that the secondary longitudinal colour aberrations of the objective are doubled in amount owing to the double passage of light through the objective. We have the secondary spectra of two such objectives added together. The diameter of the spurious disc at S_1 is the same (·0004 inch) as that which would be yielded by a 25·2-inch objective of 370 inches focal length, or by any other objective having the same ratio of focal length to aperture. I have also found that the drawing out of the cone of rays into the cylindrical form near the focus is not disturbed in amount by the fact of the reflection from the mirror and the double passage of the light through the objective.*

Thus, then, we have represented at S_1 precisely the same state of things (except for the *angular* diameter of the spurious disc) as we should have at the focus of a 25·2-inch objective of 370 inches focal length supposing it were focussed upon a very distant black line (drawn on a white ground), and of such a width that the objective would form an image of it equal in width to either our original black line at S or its image at S_1. Fig. 2 is a view *as seen from the objective* of the arrangement of slits. Fig. 3 is a view of the same from the eyepiece side. Fig. 4 is a longitudinal plan and section of the apparatus taken along the optic axis. All three views are drawn to double the original size. S — S is the original black line formed as follows :— Three steel jaws or slips, D_1, D_2, and D_3, with carefully worked straight knife edges, were clamped on to a common flat surface, the utmost care being taken to insure exact parallelism between the two edges of the second slip, D_2. Close to and parallel to the knife edge of D_1 were ruled with a dividing

* This fact, that the degree of drawing out of the cone of rays, as the focus is approached, is independent of whether the light traverses the objective twice or only once, is *fatal* to any attempt to account for this curious phenomenon by residual spherical aberration. It seems to be dependent on nothing else but the ratio between aperture and focal length or the angle of the cone of rays.

engine two fine lines ·002 inch apart, the same being done close to the slit S_1 upon the flat surface of D_2. This was for guidance in adjusting the widths of the slits formed between the contiguous knife edges. The slit S — S was adjusted to ·002 or $\frac{1}{500}$ of an inch width. The thick line K — K represents a section of a thin metal partition dividing the tube into two, and preventing any light reaching the left-hand side of the tube and the slit S_1 — S_1, which should be kept in darkness. The flat face of the slips D_1 and D_2, facing the objective and on the right hand of the partition K — K, was then smoked carefully over a piece of burning magnesium wire. This operation covers the face with a beautifully fine and pure white deposit of magnesia. At the same time, if great care is not exercised, the slit S — S gets filled up. But after a few failures I was able to get the flat faces of the two steel slips (all to the right, in fig. 3, of the partition K — K) very uniformly smoked over to a pure white, while at the same time the width of the slit S — S was reduced down as nearly as possible to a uniform width of ·001 or $\frac{1}{1000}$ of an inch. A piece of black paper, B (fig. 4), was afterwards fastened against the back face of the two jaws. Then the triangular space behind S — S formed a sort of dark well behind it. Now, the white surface being illuminated brightly by the small electric lamp, L, it is evident that the slit S — S forms an absolutely black line of $\frac{1}{1000}$ of an inch width. A line ruled with the blackest ink on a white surface is not quite black, nor is it likely that a line of only a thousandth of an inch in width could be ruled at all, at any rate perfectly enough to bear much magnification. A small rectangular slip of white paper, P, also smoked with magnesia, is then carefully fastened over the upper part of the black slit, and facing the objective, for a purpose shortly to be explained. The width of the slit S_1 — S_1 was adjusted to a trifle less than $\frac{1}{1000}$ of an inch. W in figs. 2 and 3 represents a sort of window cut out of the two steel slips, D_2 and D_3. A positive eyepiece, E, of a power of 450, which is sufficiently high to magnify the slit S_1 — S_1 to a very perceptible width (8 minutes of arc), was mounted behind the slits. The apparatus being pushed into the tube of the telescope (which has been previously adjusted) and the glow-lamp L excited to its fullest power, then a very little manipulation of the telescope will bring the reflected image of the black slit vertically across the window W, where it can be viewed by the eyepiece E and nicely focussed. Fine adjustments are then required to bring the actual slit S_1 — S_1 and the

image of the black line simultaneously into the very best focus, so as to avoid any parallax. It is already evident enough to the eye that the image of the black line, although pretty sharply defined, is not quite black, but is filled in with wasted light. We now wish to isolate this wasted light, and directly compare its brightness with the brightness of the image of the surrounding white surface. By means of a fine adjustment of the telescope the image of the black line as seen in the window can be brought into exact alignment with the slit $S_1 — S_1$. Now, it is evident enough that if the image were really black, then, on making the above adjustment, the slit $S_1 — S_1$ should go suddenly quite black. But it certainly does not do so; it goes very little darker indeed than when the image of the white surface shines through it. As a result of *contrast*, the black line in the window appears fairly dark—a dark grey—but its continuation below, as isolated by the jaws of the slit, appears a relatively bright line. Now, let it be supposed that the optic axis of the objective as well as a normal to the surface of the reflector cuts the surface of the steel strip D_2 at the point A. Then we have the image of the black line so thrown (upside down) as to fall between the limits d and b, partly across the window and partly into the slit $S_1 — S_1$ from a to b. But between the limits b and c we have the image of the white paper P (forming part of the whole white surface) thrown across the slit $S_1 — S_1$. When properly adjusted, then, we have from a to b an isolated strip of the light which is lost for defining purposes owing to the secondary colour aberrations; while from b to c we have a strip, of similar width, of the image of the white surface representing the luminous value of the *whole* light transmitted by the objective, for it is made up of both the aberrant light and the light which is strictly available for defining purposes. In carrying out this experiment any observer ignorant of the secondary spectrum would be surprised at the comparatively small difference between these two portions of the slit. I proposed to measure the relative luminosities of these two narrow strips of light, a to b and $b — c$, by placing small pieces of neutral-tint glass, g, in front of the portion of slit $b — c$ and with their upper edges at b (see figs. 2, 3, and 4) until it appeared to be of a brightness equal to the part $a — b$. I first tried a single thickness of a pale neutral-tint glass, which, by very careful and repeated experiments by means of the Rumford photometer test, I had found to transmit 56 per cent. of light. On fastening this behind

$b-c$, its brightness was reduced, but it still appeared somewhat brighter than $a-b$. I then put two such strips (which I had proved by similar tests to transmit 31 per cent. of the light, thus agreeing with calculation) behind $b-c$, and now the part of the slit $a-b$ was rather the *brighter* of the two.

Thus I judged that the brightness of the wasted light, represented by $a-b$, was about intermediate in value between 31 per cent. and 56 per cent. of the whole light (represented by $b-c$), transmitted by the objective—that is, the wasted light amounted to about 40 per cent. of the whole light transmitted by the objective. It scarcely needs pointing out that the photometric estimation of the relative brightnesses of two such narrow strips of light as these, placed end to end, renders anything like exactness impossible; I could, however, make sure of my *limits*. It should be remembered that the width of the black line and its image was $\frac{1}{1000}$ of an inch, which is about $2\frac{1}{2}$ times the diameter (·0004) of the spurious disc corresponding to each point of the original. If I had narrowed the black slit still more, say to ·0004 or so, and at the same time had been able to estimate the relative brightnesses of the parts $a-b$ and $b-c$, I should have found the percentage of wasted light in $a-b$ still greater compared with $b-c$. But tremor in the telescope might, even at the best of times, vitiate any measurements, could they be taken, with the black line and slit as narrow as that. The greatest precautions were taken to guard against vibration and currents of air; the objective had the usual colour correction, was perfectly free from spherical aberration, and perfectly squared on, and always allowed to arrive at a uniform temperature before experimenting, for slight warming and cooling give rise to negative and positive spherical aberrations respectively. The experiments were carefully repeated on several different occasions. I *never* saw, even for an instant, the part of the slit $a-b$ become darker than a bright grey when made to exactly overlap the image of the black line. I occasionally noticed tremor in the definition of the black line as seen in the window, but it was rarely enough to cause momentary encroachments of light into the slit, the measurements of whose brightness were only taken when the image of the slit in the window was seen to be perfectly steady. The width of the slit S_1-S_1 was slightly but certainly narrower than the image of the black line, so as to insure the edges of the white surfaces on either side being thoroughly hidden.

But here it might be asked whether some, if not a large part, of this

wasted light could not be accounted for by those diffraction rings which are well known to surround the spurious disc. The integrated brightness of innumerable series of such rings overlapping one another over the area of the black line might be expected to give a perceptibly luminous effect. I scarcely knew what to expect theoretically from this cause, but resolved to put it to the test of an experiment with a $3\frac{1}{2}$-inch triple objective (on the principle which I had the pleasure of bringing to your notice in March). This objective, of about 59 inches focal length, was mounted in exactly the same way as the 12·6-inch in front of the flat mirror, and exactly the same system of slits (figs. 2, 3, and 4) and eyepiece as had been used for the 12·6-inch o.-g. was applied to the $3\frac{1}{2}$ o.-g. in precisely the same way. Here a very different state of things was at once apparent. After making all the requisite adjustments, and getting the image of the black line exactly focussed into the slit S_1—S_1, the latter became almost totally black. I say almost, because I suspected a small trace of light to be present, but it was so small that it could scarcely have amounted to as much as 10 per cent. of the brightness of the white surface. At the same time I should expect to see a little residual light, owing to the above-mentioned diffractive phenomena. However, there was no mistaking the marked difference in the behaviour of the two telescopes—the first with the secondary spectrum of an ordinary 25-inch objective, and the second with practically no secondary spectrum. The latter gave more black and white definition than the former. In my paper on the secondary spectrum of November last I estimated, on theoretical grounds, that the light lost for defining purposes, owing to the secondary spectrum, in the case of a 24-inch objective of 360 inches focal length should be not less than 42 per cent. of the whole light transmitted. My experiment with the 12·6-inch objective used as its own collimator, so as to be equivalent to a 25·2-inch objective of 370 inches focal length, has left no doubt in my mind that that estimate is not an exaggerated one. Other things being equal, if we can win back to correct focus this aberrant light in the case of a 24-inch objective of 360 inches focal length, we shall then be increasing the brightness of very small stars viewed through it in the ratio of 60 to 100; in other words, we shall add 66 per cent. to their brightness, and increase space penetrating power accordingly, as well as obtain a more perfect definition upon objects presenting extension and details.

I have above described the image of the black line as seen through the little window, showing the white surface at either side, as appearing fairly dark, and I arrived at the conclusion that its real luminosity was about $\frac{2}{5}$ of that of the white surface. It then occurred to me to try the effect of viewing a narrow strip ($\frac{1}{4}$ inch wide) of neutral-tint glass transmitting 56 per cent. of light, and placed in front of a uniformly illuminated sheet of white paper placed at the end of a dark passage. I then went to such a distance off as to cause the strip of glass to present an angular diameter of from 5 to 9 minutes, and was surprised to see how much the apparent dark line formed by it stood out. It appeared of a medium grey tint. I then tried the effect of two such strips superimposed, together transmitting 31 per cent., and then at the same distance the effect was a distinctly marked line of a dark grey colour, the contrast seeming to me, if anything, greater than that visible in the case of the image of the black line seen in the window of the eyepiece in the 12·6-inch telescope.

Buckingham Works, York.
1894 *April* 10.

On the R–D Discordance. By Prof. H. H. Turner, M.A., B.Sc., and W. G. Thackeray.

[Received and read June 8, 1894.]

1. The troublesome and puzzling systematic error in Zenith Distance observations known as the R–D discordance has been the subject of much discussion and investigation since its discovery many years ago. The present paper does not profess to give a complete explanation of the discordance; but it is hoped that it gives in the first place some valuable negative evidence, by indicating directions in which it seems that the source of the discordance should *not* be sought; and secondly, a positive indication of some importance, the development of which must be left to a future paper, for the reason that though it would seem at first sight as if we were on the threshold of a complete explanation of the discordance, we have as yet found it impossible to take the final step in spite of all our efforts. It seems useless, therefore, to delay any longer the publication of results which may help other investigators, or suggest to them the clue which has not at present occurred to us. The results here published are the outcome of much work done at the Royal Observatory, Greenwich, not only by Mr. Thackeray and myself, but by other members of the staff, to whom our thanks are due for their cordial co-operation.

H. H. T.

2. It will be convenient here to summarise the investigations and general conclusions of the paper, some of which are not entirely new. There are two main sections of the paper.

A. Description of the observations (and cognate matters) in which the discordance originates, with an historical review.

B. Experimental researches on the physical cause of the discordance.

3. Each of these sections has several sub-sections, which are enumerated below, and designated by the numbers of the paragraphs devoted to them in the body of the paper.

SECTION A. HISTORICAL AND DESCRIPTIVE.

§ 4. *The manner of observing stars by reflexion* is described with attention to details in which the discordance may originate.

§ 5. *The limits of Z.D.* within which reflexion observations can be properly made are examined.

§§ 6–18. *The methods of discussing the results* in past years are examined, and the whole material for the years 1851–1890 discussed afresh. It is concluded (see § 12)—

(α) That, the period 1866–1870 being excepted, the R − D discordance has increased in magnitude, either steadily or by steps, during the period 1851–1890.*

(β) That the law of distribution in Zenith Distance has remained sensibly the same throughout the period 1851–1890 over the very limited range in Z.D. (about Z.D. 20° to 36°) available for comparisons: the discordance being nearly constant over this range on both sides of the zenith, and certainly not increasing so rapidly as would be demanded by a law "sine zenith distance."

* At the moment of going to press (1895 March 25), it occurs to us that this conclusion requires modifying. Up to 1881 the R observations were compared with *all* direct observations of the same star; from 1882 with those only made at the same transit. The results previous to 1882 should thus be increased by a fraction of the DD_0 discordance (see next page); and it is quite possible that the R − D discordance has not sensibly changed since 1851. The examination of this point, however, must be left to a future paper.

(γ) That for the exceptional period 1866–1870 there is a sudden increase, not afterwards maintained, in the magnitude referred to in (α); and a yet more sudden change in the distribution in Z.D. referred to in (β).

(δ) (see § 16) For Z.D.'s larger than 36°, we have only observations in the years 1883–1890: the magnitude of the discordance increases with the Z.D. *more* rapidly than the law "sine zenith distance" would indicate. It does not seem possible to assign a simple law which will satisfy the observed values of the discordance from Z.D. 20°–60°.

(ϵ) (§ 18) There is an annual variation in the R–D discordance.

§ 19. *The correction of Zenith Distance observations for the R–D discordance.* To the present time the R and D observations have been considered equally in error in opposite directions, and corrected accordingly. The reasons for this procedure are recalled.

This concludes section *A*, the descriptive part of the paper. We then come to

Section B. Possible Physical Causes of the R–D Discordance.

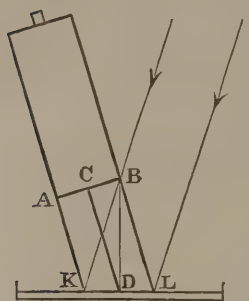
§§ 20–23. *Flexure.* It is concluded that the R–D discordance is *not* an ordinary astronomical flexure.

§§ 24–31. *Irregular Refraction.* It is concluded that the R–D discordance is *not* due to irregular atmospheric refraction near the instrument.

§§ 32–43. *The "DD_0 Discordance" and the influence of the order in which observations are made.* It is shown that there is a discordance, not only between the observations of the same star R and D, but also between observations D and D_0, using the symbol D_0 to signify a direct observation made in the ordinary way and not preceded by an R observation. The influence of error in adopted inclination of the horizontal wire is carefully considered. Further experiments are given showing that if the D observation precede the R observation the R–D discordance is *reversed in sign.* Hence the discordance depends *in some way on the history and position of the instrument near the epoch of observation.* Efforts to obtain a more definite conclusion than this have not been completely successful at the time of writing.

SECTION A.

4. *The manner of observing stars by reflexion.* Reflexion observations are made in the manner described in the Greenwich volumes. The telescope is clamped in the proper position for the reflexion observation a few minutes before the star is due, and the microscopes read. The observer then mounts the steps and watches for the appearance of the reflected image of the star, which he bisects in Z.D., generally at the earliest possible moment. He then unclamps the instrument and sets it for the direct observation; makes the bisections with the Z.D. micrometer, and finally reads the microscopes for this observation at leisure. It is important to remember that before the R. observation the telescope has been for a few minutes clamped in a downward position, while before the D. observation it is quickly moved into position only a few seconds before the observation. (This state of things is reversed when the D. observation is taken first.) Further, the R. observation is always taken on one side of the meridian, and the D. observation on the other. The consequent effect of any error in the assumed inclination of the horizontal wire will be considered below.



5. *The limits of Z.D. for reflexion observations.* Near the zenith the telescope itself will cut off some of the rays from the star. Let us call the limiting Z.D. at which the whole object-glass is filled with light θ_1; and let a be the aperture of the object-glass, λ the distance from its centre to the centre of the mercury trough (=CD which at Greenwich is kept constant). Then

$$CB = CD \tan \theta_1,$$

or

$$\tan \theta_1 = \frac{a}{2\lambda}.$$

At large zenith distances the length of the mercury trough will limit the rays received by the object-glass. Let θ_2 be the limiting Z.D. at which the O.-G. is filled with light, and l the effective length of the trough, which now becomes equal to KL in above figure. And

$$KL = a \sec \theta_2.$$

Thus

$$l = a \sec \theta_2 = 2\lambda \sin \theta_2.$$

Hence for θ_1 to be small λ should be large, and for θ_2 to be large λ should be small, and the conditions for a large range of observations are conflicting. Before 1882 the second condition need not be considered, for long before Z.D. θ_2 was reached the reflected rays were cut off by the fixed collimators. The distance λ was 23 inches; and the aperture a being 8 inches, we have approximately $\tan\ \theta_1 = \cdot 18$, or $\theta_1 = 10°$. The limit determined by the collimators, which we may call θ_3, was about 45°.

In 1882 the mounting of the collimators was altered so that they could be displaced when necessary, and reflexion observations were for the first time possible down to the limit θ_2. To make this Z.D. as great as possible, the trough was raised on its carriage by 12 inches, so that λ was diminished and θ_1 consequently increased. Their values are now approximately

$$\theta_1 = 20°,\ \theta_2 = 65°.$$

The discussion of the results and adopted formulæ. §§ 6—18.

6. At the end of each year the observations have been collected in order of Zenith Distance and divided into groups, the mean of each group being taken. Equations have then been formed to determine the coefficients of the expressions

$$a + b \sin \mathrm{Z\,D},$$

or

$$a + b \sin \mathrm{Z\,D} \cos^2 \mathrm{Z\,D},$$

which would best satisfy the observations. A list of the resulting coefficients and formulæ is given in Mr. CHRISTIE's paper "On the Systematic Errors of the Greenwich North Polar Distances" (*Mem. R.A.S.* vol. xlv.), and need not here be reproduced. But it is of considerable importance in the present investigation to determine whether the apparent changes in the R–D discordance suggested by that list have any foundation in fact. In comparing the results for the R–D of the same instrument made during the long series of years from 1851 to the present time, we must remember, *first*, that some discrepancies are accounted for by changes in the habit of presenting the results, fully described in the above paper, viz. the change in form of the assumed formulæ, the exhibition of flexure as an independent correction, &c.;

secondly, that the formulæ for years subsequent to 1882 are deduced from observations at quite different Z.D.'s from those before 1882; and, *thirdly*, that in all the observations a certain suspicion attaches to the terminal groups which have been included in the calculations, but in which it is more than possible that part of the object-glass was cut off from one or other of the causes mentioned in § 5.

7. We have therefore collected afresh, *not* the annual formulæ, but the material from which they were deduced. And as the number of observations in each year is less important than the probability that the object-glass was fully used, the doubtful terminal groups have been freely rejected in the following table. [It has not been considered necessary to go back beyond the *group* to the individual observations.]

The groups of North Stars have been collected together, whose mean N.P.D. fell between 0° and 5°, 5° and 10°, 10° and 15°, 15° and 20°; and of S. stars, the groups whose mean N.P.D. fell between 77° and 72°, 72° and 67°, 67° and 62°, 62° and 57°. Groups with mean N.P.D. outside these limits have been for the present neglected. The mean Z.D.s of these groups are 36°, 31°, 26°, and 21° in each case, and the results are given under these headings. In cases where a correction for flexure was originally applied to the observations, this correction has been annihilated to make the results comparable with those as now exhibited.

TABLE I.

	North Stars.				*South Stars.*			
Z.D.	−36°.	−31°.	−26°.	−21°.	+21°.	+26°.	+31°.	+36°.
Year.	″	″	″	″	″	″	″	″
1851	+0·09	−0·58	−0·13	...	+0·24	+0·53	+0·32	...
52	−0·12	−0·52	−1·03	...	+0·26	−0·54	+0·21	+0·67
53	0·00	...	−0·34	...	+0·01	+0·23	−0·16	...
54	−0·01	−1·44	−0·11	...	+0·59	+0·13	−0·18	+0·17
55	+0·20	−0·53	...	+0·05	+0·54	...	−0·58	+0·53
1856	...	−0·20	+0·10	...	+0·40	+0·11	...	+0·11
Mean	+0·03	−0·65	−0·30	+0·05	+0·34	+0·09	−0·08	+0·37

TABLE I.—(*continued*).

	North Stars.				South Stars.			
Z.D.	−36°.	−31°.	−26°.	−21°.	+21°.	+26°.	+31°.	+36°.
Year.	″	″	″	″	″	″	″	″
1857	...	−0·30	−0·27	...	+0·29	−0·02	−0·30	+0·09
58	...	−0·12	−0·01	...	+0·34	+0·33	−0·06	...
59	+0·50	...	+0·10	+0·46	+0·46	+0·30	+0·05	+0·63
60	−0·19	−0·45	...	−0·05	+0·39	−0·10	+0·17	+0·54
61	+0·04	+0·22	−0·28	...	−0·20	0·00	−0·47	+0·32
62	−0·20	−0·15	+0·20	...	+0·07	+0·29	+0·14	+0·09
63	−0·17	−0·33	−0·03	−0·23	−0·17	−0·01	+0·20	+0·23
64	−0·20	+0·02	−0·18	−0·01	−0·20	+0·36	−0·36	+0·58
Mean	−0·04	−0·16	−0·07	+0·04	+0·12	+0·15	−0·08	+0·35
1866	−0·12	+0·07	−0·20	−0·01	+0·70	+0·13	+0·11	...
67	−0·44	...	+0·25	+0·26	+0·18	−0·02	+0·88	...
68	...	−0·59	...	−0·25	+0·30	+0·36	+0·45	+0·89
69	−0·63	−0·62	+0·05	+0·06	+0·58	+0·61	+0·51	+1·06
70	...	−0·41	+0·58	+0·39	+0·58	+0·52	+0·42	+0·70
Mean	−0·40	−0·39	+0·17	+0·09	+0·47	+0·32	+0·47	+0·88
1871	+0·76	−0·32	−0·22	−0·30	+0·42	+0·54	+0·34	+0·65
72	−0·28	...	−0·53	−0·44	+0·39	+0·13	−0·24	+1·08
73	+0·22	+0·19	...	−0·32	+0·51	+0·36	+0·56	+0·29
74	−0·66	−0·22	−0·38	−0·51	−0·02	+0·11	+0·10	+0·29
75	−0·03	+0·01	−0·39	−0·01	+0·37	−0·10	−0·09	+0·30
76	+0·21	−0·37	−0·14	−0·10	+0·20	+0·06	+0·07	+0·31
77	−0·17	−0·20	...	+0·13	+0·16	0·00	+0·20	+0·01
78	−0·45	−0·37	...	−0·44	+0·38	+0·41	+0·20	+0·14
Mean	−0·05	−0·18	−0·33	−0·25	+0·30	+0·19	+0·14	+0·38
1879	−0·12	−0·37	+0·08	−0·64	+0·37	+0·56	+0·07	+0·52
80	−0·48	−0·26	−0·14	−0·16	+0·56	+0·20	+0·57	+0·88
81	−0·35	−0·36	−0·53	−0·34	+0·36	+0·74	+0·60	+0·83
82	+0·01	−0·27	...	−0·57	+0·44	+0·15	+0·35	+0·49
Mean	−0·24	−0·32	−0·20	−0·43	+0·43	+0·41	+0·40	+0·68

TABLE I.—(*continued*).

	North Stars.				*South Stars.*			
Z.D.	−36°.	−31°.	−26°.	−21°.	+21°.	+26°.	+31°.	+36°.
Year.	″	″	″	″	″	″	″	″
1883	−0·56	−1·09	...	−0·72	+0·35	+0·40	+0·24	+0·37
84	−0·21	...	−0·78	−0·40	+0·26	+0·24	+0·22	+0·22
85	−0·63	−0·65	−0·61	−0·83	+0·28	+0·47	+0·39	+0·26
86	−0·56	−0·68	−1·11	−0·41	+0·43	+0·44	+0·54	+0·39
87	−0·71	−0·62	−0·87	−0·64	+0·41	+0·50	+0·32	+0·82
88	−0·71	−0·66	−0·51	−0·60	+0·36	+0·36	+0·41	+0·27
89	−0·53	−0·49	−0·73	−0·17	+0·45	+0·51	+0·25	+0·31
90	−0·83	−0·12	+0·23	−0·15	+0·51	+0·15	+0·20	+0·39
91								
92								
93								
Mean	−0·59	−0·62	−0·63	−0·49	+0·38	+0·33	+0·32	+0·38

The series of years is broken as above for the following reasons.

In 1857 the value of the adopted correction for flexure was changed from $+0''\cdot50$ to $+0''\cdot56$. In 1865 September the cube of the transit circle was pierced, and, as the results before and after September may not be strictly comparable, we have rejected this year's observations. In 1871 the value of the correction for flexure was changed from $-0''\cdot37$ to $-0''\cdot12$. In 1879 the screws of the microscopes were found to be worn, and new screws were supplied. Since 1879 the adopted value for flexure has been $0''\cdot00$, but in 1882 June the old stone piers for the collimators were cut away, and the collimating telescopes remounted on cast-iron arms, which can be swung aside when not in use, and thus reflexion observations can be made as low as 70° Z.D.

There is thus a physical reason for the separation of groups in the years 1865, 1879, and 1882; but the separations of groups 1 and 2, and of groups 3 and 4, are more or less arbitrary, and a comparison of these groups will throw light on the reality of apparent changes introduced on the other occasions.

Collecting the means into a small table :

TABLE II.

Years.	−36°.	−31°.	−26°.	−21°.	+21°.	+26°.	+31°.	+36°.
1851–56	+0″·03	−0″·65	−0″·30	+0″·05	+0″·34	+0″·09	−0″·08	+0″·37
57–64	−0·04	−0·16	−0·07	+0·04	+0·12	+0·15	−0·08	+0·35
66–70	−0·40	−0·39	+0·17	+0·09	+0·47	+0·32	+0·47	+0·88
71–78	−0·05	−0·18	−0·33	−0·25	+0·30	+0·19	+0·14	+0·38
79–82	−0·24	−0·32	−0·20	−0·43	+0·43	+0·41	+0·40	+0·68
1883–90	−0·59	−0·62	−0·63	−0·49	+0·38	+0·38	+0·32	+0·38

8. It is obvious from the above figures that the accidental errors of observation are very large, particularly in the earlier years, in which the recording micrometer was not yet in use.

Without attempting to assign the exact form of the curve which best suits the observations, we may examine generally one or two of its features.

9. The figures seem to show that, whatever the phenomenon may be, it has increased in magnitude during recent years.* The means of the four groups for each period on opposite sides of the zenith are (*changing the sign for northern groups*)

TABLE III.

Years.	N. Stars.	S. Stars.	Mean of both.
1851–56	+0″·22	+0″·18	+0″·20
57–64	+0·06	+0·14	+0·10
66–70	+0·13	+0·54	+0·35
71–78	+0·20	+0·25	+0·23
79–82	+0·30	+0·48	+0·39
1883–90	+0·58	+0·37	+0·48

Thus while the mean of the three groups for the twenty years 1851–1870 is $+0''\cdot22$, that for the three in the period 1871–1890 is $+0''\cdot37$, nearly double of the former. The change does not, however, appear to be continuous, the most marked interruption being in the years 1866 to 1873, when the

* See footnote on p. 88.

discordance is much larger than in years both before and after, especially for south stars. As yet no cause has been assigned for this anomaly.

10. Next let us examine the *slope* of the curve in the neighbourhood of the mean Z.D.$\pm 28\frac{1}{2}^\circ$. If we subtract the mean value for 21° and 26° from that for 31° and 36° (reversing the sign for N. stars) we get

Table IV.

Years.	N. Stars.	S. Stars.	Mean N. and S.
1851–56	$+0''.18$	$-0''.07$	$+0''.05$
57–64	$+0.08$	0.00	$+0.04$
66–70	$+0.53$	$+0.28$	$+0.40$
71–78	-0.17	$+0.01$	-0.08
79–82	-0.04	$+0.12$	$+0.08$
1883–90	$+0.05$	-0.03	$+0.01$

Excepting during the period 1866–1870, therefore (above noted as anomalous), the slope of the curve has remained small on both sides of the zenith, so that the mean of the four groups at the successive Z.D.s applies nearly uniformly to the whole of the observations within the range of Z.D. under consideration. With the assumed law for the R−D, a term $1''.00$ sin Z.D. would have the following values at the Z.D.s named:

21°	26°	31°	36°
$0''.36$	$0''.44$	$0''.52$	$0''.59$

and excess of mean of last two over first two$=0''.16$, a much larger quantity than any of those found above except the anomalous third. It was remarked above that the anomalous values in the series did not cease at the end of the period 1866 to 1870, but seemed to run on to 1873. For the years 1871 to 1873 the values for slope formed as above would be

$$\text{for North Stars} \quad -0''.45$$

and

$$\text{for South Stars} = +0.14\,;$$
$$\text{Mean} = -0.16.$$

So that in this respect the character of the period 1866–1870 is not maintained in 1871–1873. The remainder of the period 1874–1878 gives

for North Stars $-0''.02$,
for South Stars $+0.04$.

11. Thirdly, as regards the symmetry of the phenomenon about the zenith, the mean values for N. and S. stars given above in Table IV. show that there is no sensible asymmetry excepting during the anomalous period.

12. To sum up this examination of the results for the years 1851–1890, it appears

(*α*) That the period 1866–1870 being excepted, the R−D discordance has increased in magnitude, either steadily throughout or by steps.*

(*β*) That the law of distribution in Z.D. has remained sensibly the same throughout the period 1851–1890 over the very limited range in Z.D. (about 20° to 36°) available, the discordance being nearly constant over this range on both sides of the zenith, and at any rate not increasing so rapidly as would be demanded by the law sin Z.D.

(*γ*) That for the period 1866–1870 there is a sudden increase, not afterwards maintained, in the magnitude referred to in (*α*); and a yet more sudden change in the distribution in Z.D. referred to in (*β*).

13. Since 1882 a much greater range of zenith distance has been available for reflexion observations. The results for different years have been satisfactorily accordant, as the following formulæ for the separate years, taken from the printed observations, will show:

TABLE V.

Formula for R−D.

1883	$-0''.038+1''.226\times\sin$ Z.D.	1887	$-0''.028+1''.206\times\sin$ Z.D.
84	$-0.053+1.156\times\sin$ Z.D.	88	$+0.020+1.332\times\sin$ Z.D.
85	$-0.036+1.215\times\sin$ Z.D.	89	$-0.024+1.194\times\sin$ Z.D.
1886	$+0.012+1.301\times\sin$ Z.D.	1890	$-0.028+0.952\times\sin$ Z.D.

To show how far this formula suits the observations, the residuals for the separate groups are given in each volume. These are collected below in Table VI., which table will be easily understood, remarking that—

First, care having been taken to break up the observations into nearly

* See footnote on p. 88.

the same groups each year, there is no difficulty in arranging the groups under the same approximate Z.D.

Secondly, terminal groups whose value is doubtful, from reasons given in § 5, are separated from the others, and ultimately rejected.

Thirdly, the signs of the quantities for north stars have been reversed so as to be comparable with those of south stars at the same zenith distance.

TABLE VI.

R—D Residuals.

North Stars.

Mean N.P.D. of Group.	−30°.	−27°.	−25°.	−23°.	−20°.	−17°.	−13°.	−9°.	−3°.	+3°.	+9°.	+15°.	+18°.	+22°.	+26°.	+29°.
1883	0″·00	−0″·09	+0″·98	+0″·67	+0″·17	+0″·09	−0″·40	−0″·32	−0·24	−0·30	+0″·41	+0″·16	+0″·16	−0″·09	−0″·25	−0″·97
84	+0·06	−0·16	+0·17	+0·36	+0·84	+0·24	−0·67	−0·29	+0·10	−0·62	+0·10	−0·16	−0·16	−0·08	−0·50	−0·19
85	−0·16	−0·42	+0·20	+0·12	+0·80	+0·32	+0·12	−0·09	−0·57	−0·17	−0·07	+0·16	+0·31	+0·23	−0·48	−0·31
86	−0·46	−1·04	+0·33	+0·23	+0·52	+0·31	+0·18	−0·23	−0·18	−0·28	−0·03	+0·52	−0·09	0·00	−0·18	−0·04
87	−1·13	−0·95	+0·28	−0·01	+0·23	+0·23	−0·27	−0·02	−0·17	−0·11	−0·09	+0·19	+0·12	+0·55	+0·37	−0·46
88	−0·74	−0·17	+0·09	+0·82	+0·13	+0·62	−0·26	+0·16	−0·26	−0·14	−0·05	−0·08	+0·11	−0·45	−0·73	−0·21
89	−0·33	−0·14	+0·02	+0·06	+1·10	+0·13	−0·05	+0·40	−0·57	−0·28	−0·21	−0·10	−0·33	−0·41	+0·01	+0·01
1890	−0·44	+0·10	−0·67	+0·23	+0·62	+0·09	−0·11	+0·25	−0·60	+0·15	−0·46	−0·72	−0·28	+0·05	+0·32	+0·41
Mean	−0·40	−0·36	+0·18	+0·31	+0·55	+0·25	−0·18	−0·02	−0·31	−0·22	−0·05	0·00	−0·02	−0·03	−0·18	−0·22

South Stars.

Mean N.P.D. of Group.	+51°.	+58°.	+63°.	+65°.	+69°.	+72°.	+76½	+81⅓	+86½	+90½	+94½	+98	+100⅓	+103½	+107
1883	+0″·09	+0″·07	+0″·18	+0″·18	+0″·59	+0″·33	+0″·43	+0″·54	−0″·12	+0″·08	+0″·36	0″·00	−0″·06	−0″·64	−0″·88
84	+0·27	+0·15	+0·15	+0·42	+0·44	+0·39	+0·54	+0·35	−0·34	−0·30	−0·95	−0·23	−0·32	+0·07	−0·73
85	−0·68	+0·17	−0·03	+0·19	+0·28	+0·29	+0·29	−0·04	+0·01	−0·11	−0·18	+0·31	−0·06	−0·66	−1·12
86	−0·57	+0·08	−0·19	+0·59	+0·21	+0·19	+0·75	+0·41	−0·16	+0·22	−0·34	−0·18	−0·52	−0·11	−0·89
87	−0·19	+0·02	−0·02	+0·14	+0·36	+0·39	−0·02	−0·13	+0·09	+0·05	−0·41	−0·66	−0·40	+0·86	−0·62
88	−0·39	+0·17	+0·67	−0·05	+0·37	+0·60	+0·03	−0·21	−0·15	−0·18	+0·01	−0·25	−0·30	−0·39	−0·47
89	−0·20	0·00	−0·05	+0·16	+0·40	+0·57	+0·37	+0·36	+0·11	−0·13	−0·55	−0·05	−0·55	−0·86	−1·82
1890	−0·07	−0·07	−0·17	+0·33	+0·40	+0·31	+0·26	+0·14	+0·05	−0·08	−0·16	−0·35	−0·33	−0·22	−0·10
Mean	−0·22	+0·08	+0·07	+0·25	+0·38	+0·38	+0·33	+0·18	−0·06	−0·06	−0·28	−0·18	−0·32	−0·24	−0·83

14. It will be in many ways convenient to replace the arbitrary zenith distances of the above table by the definite points 15°, 20°, 25°, &c. . . . 68°, both N. and S. of the zenith. Taking out the values for these points by simple interpolation, we get

TABLE VII.

R–D Residuals (Errors of Formula).

Z.D.	N. Stars.	S. Stars.	Mean.
°	″	″	″
15	+0·10	−0·12	
20	+0·03	+0·08	
25	0·00	+0·12	+0·06
30	+0·05	+0·35	+0·20
35	+0·20	+0·36	+0·28
40	+0·28	+0·23	+0·26
45	+0·15	+0·08	+0·12
50	+0·12	−0·06	+0·03
55	−0·20	−0·22	−0·21
60	−0·34	−0·21	−0·28
65	+0·20	−0·24	
68	+0·40	−0·83	

The untrustworthiness of the terminal groups which are separated in both Tables VI. and VII. from those when the full aperture of the object-glass was in use (see § 5) is well shown by the disagreement between north and south stars, which are naturally affected in opposite directions.

15. Confining our attention to the groups from Z.D. 25° to 60°, we see that the theoretical formula (1″·2 sin Z.D.) increases too rapidly at small, and not rapidly enough at large, zenith distances; in fact we could suit the observations better by introducing a higher power of sin Z.D., such as $\sin^3$ Z.D. We must remark, however, that the coefficient of $\sin^3$ Z.D. is to be *positive*, and that a formula such as

$$b \sin \text{Z.D.} \cos^2 \text{Z.D.} = b \sin \text{Z.D.} - b \sin^3 \text{Z.D.}$$

(which was formerly in use) does not suit the observations so well as the simple sin Z.D.

16. If we subtract from the value of $1''\cdot20$ sin Z.D. as given in the second column of Table VIII., the error of formula shown in Table VII., so far as to get virtually the observed R−D during the eight years 1883–1890 at the zenith distances 25°–60°, as in column four of Table VIII., we can determine the coefficients of the expression

$$b \sin \text{Z.D.} + c \sin^3 \text{Z.D.}$$

TABLE VIII.

Z.D.	$1''\cdot2$ sin Z.D.	Error of Formula.	Observed R−D (O).	$R_1 =$ 0·49 sin Z.D. + 1·43 sin³ Z.D.	$R_1 - O$.
°	"	"	"	"	"
25	+ ·50	+0·06	+0·44	+0·33	−0·11
30	+ ·60	+0·20	+0·40	+0·43	+0·03
35	+ ·68	+0·28	+0·40	+0·56	+0·16
40	+ ·77	+0·26	+0·51	+0·69	+0·18
45	+ ·85	+0·12	+0·73	+0·82	+0·09
50	+ ·91	+0·03	+0·87	+1·02	+0·15
55	+ ·98	−0·21	+1·19	+1·10	−0·09
60	+1·03	−0·28	+1·31	+1·37	+0·06

so as best to satisfy these observed values. The values $+0''\cdot49$ for b and $+1''\cdot43$ for c give the numbers in column five of Table VIII., which suit the observations better than the adopted formula; but a very little trial is sufficient to show that we cannot hope to represent the observations by any single formula which satisfies the following conditions:

(1) Of being simple enough to admit of a physical explanation.

(2) Of not becoming extravagantly large (numerically) at the zenith or horizon.

(3) Of remaining nearly constant from Z.D. 25° to 40°.

(4) Of increasing with sufficient rapidity from Z.D. 40° to Z.D. 60°.

17. It is, however, quite possible that the phenomenon under examination is not simple, but is best represented by an aggregation of formulæ. If, for instance, the irregular refraction of the unequally heated air near the telescope be responsible for any considerable portion of the R−D discordance,

we might expect the proper formula to be incapable of any simple representation algebraically. It would thus appear advisable to defer the consideration of this question until the possible physical causes of the discordance have been dealt with more fully.

Annual Variation in the R–D Discordance.

18. In a short paper recently communicated to the Society (*Monthly Notices*, vol. lii. p. 374) it has been shown that the R–D discordance does not remain sensibly constant throughout the year. The results for the years 1883–1890 being collected, and distributed according to the month of observation, the coefficients in the formula $a+b$ sin Z.D. for each month were found to be as follows:

TABLE IX.

	a	b		a	b		a	b
Jan.	$-0''.01$	$+0''.97$	May	$-0''.11$	$+1''.49$	Sept.	$-0''.04$	$+1''.14$
Feb.	-0.01	$+0.93$	June	-0.09	$+1.47$	Oct.	-0.06	$+1.12$
Mar.	-0.01	$+1.13$	July	-0.07	$+1.37$	Nov.	0.00	$+1.09$
April	-0.04	$+1.29$	Aug.	-0.06	$+1.22$	Dec.	-0.04	$+0.99$

The Correction of Zenith Distance Observations for the R–D Discordance.

19. Given a satisfactory formula for expressing the discordance between R and D observations, it yet remains to be determined whether the R. observations are to be taken as erroneous to that extent and corrected accordingly; or whether perhaps the R observations are correct and the D observations require correction so as to agree with them; or whether finally both are erroneous. In the last case we must further determine the fraction of the discordance applicable to the R and D observations respectively, which fraction may quite conceivably vary with the zenith distance.

It has been the custom at Greenwich to assume that the R and D observations are equally erroneous in opposite directions, and to correct each accordingly by half the amount of the discordance. This practice was instituted by Sir G. B. AIRY during his directorship of the Cambridge Observatory (1829–1835), and confirmed in 1863 on an examination of various results obtained at Greenwich. His memoir "On the Discordance of Direct

and Reflexion Observations" (*Mem. R.A.S.*, vol. xxxii. p. 9) is of such historical importance that it would seem proper here to quote at some length from it. The following extracts are accordingly reproduced :

"From the first week of observations at Cambridge, it was seen that there was a systematic discordance betwen the zenith points obtained from northern stars and from southern stars. The same result exhibited itself in a different form, on reducing all circle observations to zenith distances and north polar distances, by application of the one adopted zenith point, when it appeared that on one side of the zenith the north polar distances from reflexion observations were always algebraically greater, and on the other side of the zenith always algebraically less than those from direct observations. I remember that Mr. Pond once told me that he had been troubled with similar discrepancies.

"One of my earliest Memoirs upon Observing Astronomy was a communication to the Philosophical Society of Cambridge on the Latitude of the Cambridge Observatory. In this I described at some length the discordance of which I have spoken, and I adopted for the true apparent zenith distances of the stars the mean between the apparent zenith distance given by direct observation and that given by reflexion observation.

"From that time to the present I have always used the same principle of adopting the mean between the result of direct observation and the result of reflexion observation."

. . . . "In preparing for the formation of the new Seven-year Greenwich Catalogue of Stars, it appeared to me desirable to examine carefully the results of the reductions (now extending over a quarter of a century) which have been conducted on the principle that I have described, with the view of ascertaining whether the direct observations ought to be used alone, or whether the reflexion observations ought to be used alone, or whether the mean of them ought to be used, as has been done in the annual reductions. It is my object at present to lay the result of this inquiry before the Royal Astronomical Society."

The inquiry is conducted as follows :

The observations from 1836–1860 fall naturally into three groups.

1836–41	two or one mural circles,		shutter opening	6 inches
1842–48	one mural circle	...	"	2 feet
1851–60	transit circle ...	...	"	3 "

The mean resulting colatitude of the instrument is deduced for the three periods on the three different assumptions mentioned above, viz.:

(*a*) D observations correct, R observations erroneous.

(*b*) D and R observations equally erroneous.

(*c*) D observations erroneous, R observations correct.

The seconds of resulting colatitude being as follows:

TABLE X.

	(*a*)	(*b*)	(*c*)
	″	″	″
1836–41	21·57	21·77	21·97
1842–48	21·83	21·83	21·83
1851–60	22·08	21·85	21·62

And since the results in column (*b*) are most accordant, it is concluded that supposition (*b*), which had been adopted in practice, is satisfactory.

"It appears from this that the correction $\frac{1}{2}(R-D)$ is a real correction founded upon some physical cause. Upon this I would first remark that I do not conceive that there is any room for explanation from defects of the instruments." The most careful attention had been paid to division errors *and horizontal flexure.* "A suggestion may, however, be offered as to the nature of the physical cause of R−D," the suggestion being that it depends on the width of shutter opening, which was different in the three periods as above shown. And with this suggestion, which he regards as satisfactory, Sir GEORGE AIRY leaves the discussion.

At this epoch we are not so readily inclined to accept an argument based on the comparative behaviour of different instruments; but it does not seem advisable to dwell further on this point. The suggestion as to the shutter opening is more or less dealt with in the discussion in §§ 24–31, on "Irregular Refraction."

SECTION II.

Astronomical Flexure as a Possible Cause of the R–D Discordance. §§ 20–23.

20. The flexure correction is due to the resultant error caused by the bending in the two ends of the instrument. The Greenwich Transit Circle was one of the first of the large modern instruments, and owing to the strength and stability imparted to it, especially when compared with the less

solid telescopes it superseded, it has always been considered that any error due to such a cause must be small and sensibly constant. In the earlier years (1851–1879) a constant correction derived from a few observations made at irregular intervals was used for years at a time, and applied, together with the division errors, to the observed circle readings. Since 1879 no correction has been applied for flexure independent of the R−D correction, for which the law of $a+b$ sin z is adopted. The reasons for this change will be found in Mr. Christie's papers on "The Systematic Errors of the Greenwich North Polar Distances" (*Mem. R.A.S.*, vol. xlv.). It is there shown that the flexure cannot be readily distinguished from the variable term of the R−D correction. At the same time observations of horizontal flexure by means of the collimators give a very small coefficient, which does not accord with the result of R−D observations. To regard the R−D discordance as a simple flexure is to discredit the observations of horizontal flexure for some unknown reason. The assumption that the adopted values for flexure which were derived from observation on the collimators must be necessarily wrong, because they differ from the value deduced from the variable term of R−D, can only be established by the further assumptions that R−D is entirely flexure, and, further, that the flexure is strictly conformable to the law of the simple sine zenith distance. Professor Newcomb, in his paper on "The North Polar Distances of the Greenwich Transit Circle" (*Astronomical Papers issued by the American Nautical Almanac Office*, vol. ii. p. 416), considers that it is quite possible that the system of setting one collimator on the other by looking through the cube of the instrument, instead of viewing the collimators in their entirety with the instrument raised, may very probably be the cause of a difference of $0''\cdot7$ in the later and earlier determination of flexure, that is, that there ought to be a systematic difference of $0^{r}\cdot050$ between the readings of the south collimator micrometer, according as the north collimator is viewed with the instrument raised, or through the cube. In 1884 observations were specially made to test this point, but the readings were found to be practically the same, whether the north collimator was viewed with the instrument raised or through the cube. In the case of the vertical wires such a difference is found to exist, and a correction applied to the observed collimation error.

TABLE XI.

Date.	Flexure Observed.	Flexure Adopted.	Date.	Flexure Observed.	Flexure Adopted.
	″	″		″	″
1850 Dec.	+0·42		1884 June 3	−0·47	0·00
1851 Feb.	+0·88	+0·50	1884 Sept. 9	+0·90	
1852 Dec.	+0·20	(1851–56)	1884 Sept. 29	+0·31	
1857 Jan. 5	+0·46		1884 Oct. 6	−0·03	
1857 Jan. 21	+0·66		1884 Oct. 20	+0·26	
1860 Aug.	+0·92	+0·56	1885 May 20	+0·08	
1860 Sept.	+0·67	(1857–64)	1885 July 30	−0·08	
1864 Sept.	+0·76	+0·76	1885 Nov. 25	+0·07	
1867 Apr.	−0·34	(1865)	1886 Mar. 13	+0·15	
1867 May	−0·41	−0·37	1886 May 11	+0·42	
1871 Jan.	−0·12	(1866–70)	1886 Oct. 21	−0·16	
1872 Jan.	+0·02		1886 Nov. 26	+0·13	
1873 May	−0·19		1887 Apr. 28	−0·15	
1877 Jan. 31	−0·23	−0·12	1887 Apr. 29	−0·17	
1877 Jan. 31	−0·31*	(1871–78)	1887 May 2	−0·13	
1877 Feb. 1	−0·05		1887 Sept. 14	+0·12	
1877 Feb. 1	−0·05*		1887 Oct. 10	+0·02	
1879 Apr. 22	+0·26	0·00	1888 Feb. 28	−0·11	
1879 Apr. 23	+0·07	(Since 1879 Jan. 1)	1888 Apr. 10	+0·28	
1880 Apr. 6	+0·19		1888 Apr. 12	+0·13	
1880 May 6	+0·04		1889 Jan. 28	+0·08	
1880 July 22	+0·04		1889 Apr. 18	+0·52	
1880 Dec. 3	+0·20		1889 May 12	+0·26	
1881 May 2	+0·13		1890 Jan. 14	+0·05	
1881 May 10	+0·18		1890 Jan. 15	+0·28	
1882 Jan. 3	+0·03		1890 Apr. 9	+0·43	
1882 Dec. 30	−0·07		1890 Apr. 9	+0·27	
1883 May 10	−0·78		1890 June 19	+0·47	
1883 May 18	−0·31		1890 Sept. 29	−0·35	
1883 Oct. 31	−0·39		1892 Dec. 27	−0·04	
1883 Nov. 2	−0·83		1892 Dec. 29	−0·22	
1883 Nov. 8	−0·21		1892 Dec. 31	−0·12	

* With the four supplementary microscopes.

21. It is possible that there may be some other systematic error in the determinations of horizontal flexure, but for the present we shall assume that it is not so, since none has been established. The observations are made in the ordinary way (except for the observation through the cube as above), and they will be considered to give the ordinary coefficient of horizontal flexure. For convenience of reference, Table XI. is here given showing *all* the separate determinations of horizontal flexure made since the instrument was erected, together with the adopted values used in the reductions to 1879.

22. It will be seen from this table that the coefficient is in general small; but as the observations had been somewhat few and irregular, a special series, given in Table XII., was made in 1893 for the purposes of the present investigation.

Column 1 gives the date in G.M.T.

Column 2 the observed coefficient of horizontal flexure.

Columns 3 and 4 the readings of the interior and exterior thermometers. It was thought that the coefficient found might vary with the temperature.

Column 5 gives the initials of the observers who read the telescope-micrometer and microscopes respectively. The initials T., H. F., C. M., O. T., R. C., D. E., A. B., J., A. C., refer to Mr. THACKERAY, Mr. FURNER, Mr. MARTIN, Mr. TUCK, Mr. CHEESEMAN, Mr. EDNEY, Mr. BELL, Mr. JOHNS, and CROMMELIN respectively.

TABLE XII.

1893.			Flexure.	Int. Ther.	Ext. Ther.	Observers.	1893.			Flexure.	Int. Ther.	Ext. Ther.	Observers.
	d	h	″	°	°			d	h	″	°	°	
Feb.	28	4	+0·35	...	42·7	T. & H. F.	Mar.	23	4	−0·26	55·2	57·9	T. & H. F.
Mar.	1	22	+0·07	50·8	52·0	T. & H. F.		23	22	−0·06	48·9	50·6	T. & H. F.
	3	22	0·00	50·5	50·8	T. & H. F.		24	4	+0·27	55·0	57·0	T. & H. F.
	5	22	−0·03*	49·4	48·2	T. & H. F.		24	22	+0·09	47·7	48·8	T. & H. F.
	8	4	+0·61	55·0	55·1	T. & C. M.		26	22	+0·48*	46·7	46·3	T. & O. T.
	10	22	+0·06	46·1	46·0	T. & H. F.		27	4	+0·41	51·0	51·6	T. & O. T.
	14	4	−0·07	50·9	50·3	T. & H. F.		27	22	+0·06	48·0	50·0	T. & H. F.
	21	4	−0·38	...	50·0	T. & H. F.		28	4	+0·35	53·0	52·2	T. & H. F.
	21	22	−0·20	44·6	43·7	T. & H. F.		28	22	+0·38	46·6	48·7	T. & H. F.
	22	22	−0·10	44·5	42·6	T. & H. F.		29	4	+0·58	...	...	H. F. & O. T.

TABLE XII.—(*continued*).

1893.	Flexure.	Int. Ther.	Ext. Ther.	Observers.	1893.	Flexure.	Int. Ther.	Ext. Ther.	Observers.
d h	″	°	°		d h	″	°	°	
Mar. 29 22	+0·55	49·5	55·5	T. & O. T.	Apr. 26 4	+0·39	62·2	63·6	H. F. & O. T.
Apr. 1 1	+0·36	59·5	63·9	T. & H. F.	26 23½	−0·09	54·3	53·5	T. & O. T.
4 4	+0·52	54·5	55·0	T. & C. M.	27 4	+0·13	57·0	56·5	T. & O. T.
4 23	+0·19	50·7	50·8	H. F. & O. T.	27 23	+0·48	56·4	57·0	T. & H. F.
5 4	+0·05	50·5	48·7	H. F. & O. T.	28 4	+0·54	58·9	61·9	T. & H. F.
5 22	+0·16	48·9	48·4	T. & O. T.	28 22	−0·07	54·2	54·6	T. & H. F.
7 4	−0·01	57·7	60·4	T. & O. T.	30 22	+0·04*	52·2	54·1	T. & O. T.
7 22	−0·45	46·2	43·3	H. F. & O. T.	May 1 4	−0·05	56·8	59·3	T. & O. T.
9 22	+0·21*	49·4	53·6	T. & H. F.	1 22	0·00	54·9	58·4	T. & O. T.
10 4	+0·19	56·8	60·1	T. & O. T.	2 4	+0·20	59·2	61·5	T. & O. T.
10 22	+0·07	46·4	44·0	T. & O. T.	2 22	−0·04	57·0	59·7	H. F. & O. T.
11 4	+0·19	47·6	46·7	T. & O. T.	3 4	+0·25	60·0	64·7	H. F. & O. T.
11 22	+0·10	44·1	43·7	T. & O. T.	3 22	−0·16	57·2	60·4	H. F. & O. T.
12 22	−0·20	45·5	46·0	H. F. & O. T.	4 4	+0·72	65·2	73·5	T. & O. T.
13 4	−0·17	47·6	48·0	H. F. & O. T.	4 22	+0·51	61·5	67·9	H. F. & J.
13 22	+0·18	46·1	46·2	T. & O. T.	4 23	+0·79	63·3	65·4	H. F. & J.
14 4	−0·06	50·4	51·6	H. F. & O. T.	5 4	+0·06	60·7	60·2	T. & H. F.
14 22	+0·21	51·0	52·7	H. F. & O. T.	5 22	+0·06	55·9	59·9	T. & H. F.
17 3	−0·17	48·9	47·7	T. & H. F.	7 22	+0·03*	53·3	58·1	T. & H. F.
17 22	+0·18	53·6	59·7	H. F. & O. T.	8 4	+0·05	58·5	61·5	H. F. & O. T.
18 4	+0·29	58·3	64·1	T. & O. T.	9 4	−0·11	61·2	65·1	H. F. & O. T.
18 22	+0·07	57·7	64·8	H. F. & O. T.	9 23	−0·06	58·8	65·0	T. & O. T.
19 4	−0·10	60·9	66·5	H. F. & O. T.	11 4	+0·23	62·4	67·1	T. & H. F.
19 22	+0·14	58·2	66·1	T. & O. T.	11 22	−0·07	58·4	66·6	H. F. & O. T.
20 4	+0·36	65·5	72·5	T. & O. T.	12 3	+0·30	63·8	73·6	H. F. & O. T.
20 22	+0·05	61·2	67·5	T. & H. F.	12 22	+0·09	62·6	65·1	T. & H. F.
21 4	+0·36	65·4	68·1	T. & H. F.	14 22	+0·93	67·3	73·0	H. F. & O. T.
21 22	+0·14	57·0	58·0	T. & H. F.	15 4	−0·04	66·0	68·0	T. & H. F.
23 22	+0·48*	60·2	66·3	T. & H. F.	15 22	+0·07	61·6	64·7	T. & H. F.
24 4	+0·64	64·5	69·2	T. & O. T.	18 22	+0·06	59·3	62·0	T. & H. F.
24 23	+0·58	62·5	67·0	T. & H. F.	19 4	+0·24	62·4	64·4	T. & H. F.
25 22	+0·32	57·8	61·0	T. & H. F.	22 22	+0·15	62·1	66·0	T. & O. T.

TABLE XII.—(*continued*).

1893.	Flexure.	Int. Ther.	Ext. Ther.	Observers.	1893.	Flexure.	Int. Ther.	Ext. Ther.	Observers.
d h	"	°	°		d h	"	°	°	
May 23 4	+0·46	63·4	66·6	T. & O. T.	June 19 22	+0·46	64·6	59·5	T. & H. F.
23 22	−0·06	60·1	61·0	H. F. & O. T.	20 4	+0·20	65·7	63·3	T. & H. F.
25 4	+0·50	66·7	70·2	T. & O. T.	20 22	+0·32	61·6	62·9	T. & A. B.
25 22	−0·01	59·8	57·4	H. F. & O. T.	21 22	+0·64	64·8	71·7	H. F. & A. B.
26 4	+0·06	60·7	60·3	H. F. & O. T.	22 4	+0·24	67·4	71·7	H. F. & A. B.
26 22	+0·07	59·6	60·3	H. F. & O. T.	22 22	+1·00	59·4	62·3	T. & A. B.
28 22	+0·13*	61·3	60·1	H. F. & O. T.	23 4	+0·40	63·6	65·6	T. & A. B.
29 22	−0·10	55·3	50·7	H. F. & O. T.	23 22	+0·22	58·5	57·6	H. F. & A. B.
30 4	+0·06	57·4	56·2	H. F. & O. T.	25 22	+0·13*	59·7	60·3	H. F. & A. B.
31 22	+0·03	54·8	58·2	T. & O. T.	26 4	+0·08	62·1	69·4	H. F. & A. B.
June 1 22	+0·05	56·8	61·7	T. & O. T.	26 22	+0·58	64·5	68·0	H. F. & O. T.
5 22	−0·21	59·5	61·0	T. & O. T.	27 4	+0·26	66·1	67·0	H. F. & A. B.
6 4	−0·15	63·5	68·4	T. & O. T.	27 22	+0·47	64·7	68·2	T. & A. B.
6 22	+0·06	61·5	66·0	T. & O. T.	28 22	+0·15	62·2	64·9	H. F. & A. B.
7 22	+0·14	60·6	62·1	T. & O. T.	29 4	+0·08	64·9	68·0	H. F. & A. B.
8 4	+0·16	...	...	T. & O. T.	29 22	+0·14	63·9	69·6	H. F. & O. T.
9 4	+0·02	65·3	71·2	T. & R. C.	30 4	+0·25	69·4	79·2	H. F. & O. T.
9 22	−0·02	58·5	59·0	T. & O. T.	30 22	+0·20	66·1	70·9	H. F. & O. T.
11 22	+0·16*	58·2	56·3	T. & H. F.	July 2 22	+0·47*	67·5	69·9	H. F. & O. T.
12 4	+0·03	61·9	67·9	T. & H. F.	3 4	+0·78	71·2	78·0	H. F. & O. T.
12 22	−0·07	62·7	70·7	T. & H. F.	3 22	−0·17	64·9	65·7	O. T. & A. B.
13 4	+0·87	67·0	73·4	T. & H. F.	4 4	+0·54	67·7	63·6	O. T. & A. B.
13 22	+0·12	65·4	74·6	T. & H. F.	4 22	−0·26	65·2	65·0	O. T. & A. B.
14 4	+0·35	70·2	80·9	H. F. & D. E.	5 4	+0·57	69·6	72·6	H. F. & A. B.
14 22	−0·07	67·3	74·1	T. & H. F.	6 22	+0·47	68·7	77·3	H. F. & O. T.
15 4	+0·32	72·2	75·4	T. & H. F.	7 4	−0·04	78·0	85·9	O. T. & A. B.
15 22	+1·19	...	...	H. F. & A. B.	7 22	+0·03	77·7	83·4	O. T. & A. B.
15 23	+1·38	72·9	76·2	H. F. & J.	9 22	+0·33*	66·8	71·7	H. F. & O. T.
16 4	+0·06	73·1	...	T. & H. F.	10 4	+0·41	69·7	73·8	H. F. & O. T.
16 22	−0·03	69·8	79·4	T. & H. F.	11 4	+0·39	69·5	71·7	H. F. & O. T.
18 22	0·00*	68·4	77·1	T. & A. B.	11 22	+0·07	65·2	64·0	O. T. & A. B.
19 4	−0·27	74·8	...	T. & A. B.	12 4	−0·06	63·8	63·0	O. T. & A. B.

TABLE XII.—(*continued*).

1893.	Flexure.	Int. Ther.	Ext. Ther.	Observers.	1893.	Flexure.	Int. Ther.	Ext. Ther.	Observers.
d h	″	°	°		d h	″	°	°	
July 13 4	−0·08	63·6	62·3	O. T. & A. B.	July 24 4	+0·42	69·7	75·0	O. T. & A. B.
13 22	−0·32	60·1	56·1	O. T. & A. B.	24 22	+0·10	65·4	66·8	O. T. & A. B.
14 4	+0·37	61·6	59·1	H. F. & O. T.	25 4	+0·27	69·6	67·0	T. & O. T.
14 22	+0·16	58·9	58·0	H. F. & O. T.	25 11	+0·17†	63·5	59·7	H. F. & A. C.
16 22	+0·21*	62·1	64·0	O. T. & A. B.	25 21	+0·31	64·1	61·6	O. T. & A. B.
17 4	+0·20	64·4	67·6	O. T. & A. B.	26 4	+0·21	64·8	62·8	O. T. & A. B.
17 22	+0·29	61·6	63·3	H. F. & O. T.	27 4	−0·01†	64·4	65·2	H. F. & A. B.
18 4	+0·52	65·8	71·0	O. T. & A. B.	27 4	+0·18	64·4	65·2	H. F. & A. B.
18 23	+0·37	64·0	61·5	H. F. & O. T.	27 22	+0·12	62·2	64·0	O. T. & A. B.
19 4	+0·27	65·8	66·9	O. T. & A. B.	28 4	+0·08†	66·3	72·8	O. T. & A. B.
19 22	+0·64	63·9	64·5	H. F. & O. T.	28 4	+0·13	65·8	72·6	O. T. & A. B.
20 4	+0·19	65·1	69·8	H. F. & O. T.	28 22	+0·18	64·6	72·1	H. F. & O. T.
20 22	+0·23	64·6	69·7	O. T. & A. B.	31 4	+0·19†*	62·9	60·8	O. T. & A. B.
21 4	+0·32	66·8	69·9	O. T. & A. B.	31 7	+0·20†	61·9	59·7	H. F. & O. T.
21 22	−0·02	64·4	61·2	O. T. & A. B.	31 22	+0·10†	60·0	60·2	T. & H. F.
23 22	+0·41*	66·2	68·3	H. F. & O. T.	Aug. 17 23	+0·69	82·4	86·1	H. F. & O. T.

23. The probable error of a single determination is $\pm 0''\!\cdot\!18$, and the mean of all gives for the horizontal flexure

$$+0''\!\cdot\!15 \pm 0''\!\cdot\!013.$$

There can thus be no doubt of the discrepancy between horizontal flexure and the R − D discordance, the correction to direct observations adopted for the latter being $+0''\!\cdot\!5$ or $+0''\!\cdot\!6$ instead of $+0''\!\cdot\!15$. As regards the variation of flexure with temperature, we obtain by arranging the above results in groups

Temp.	44°	48°	52°	58°	62°	67°	75°
Flexure	$-0''\!\cdot\!02_{6}$	$+0''\!\cdot\!09_{12}$	$+0''\!\cdot\!04_{16}$	$+0''\!\cdot\!14_{25}$	$+0''\!\cdot\!19_{43}$	$+0''\!\cdot\!20_{39}$	$+0''\!\cdot\!35_{32}$

the suffixes indicating the numbers of observations in the groups. There

* The instrument was raised between this and the previous observation.

† This observation was made with the illumination of an electric lamp.

would thus seem to be a sensible variation of the observed coefficient with temperature, but the variation is not large enough to help us in explaining the discrepancy between flexure and the R−D discordance. We are driven to the conclusion that *the R−D discordance is not a simple astronomical flexure.*

Irregular Refraction as a possible Cause of the R−D Discordance.
§§ 24–31.

[The deductions and opinions expressed in this section are mine individually.—H. H. T.]

24. It has long been admitted that the unequally heated strata of air in the neighbourhood of the instrument must cause irregular refraction, but I know of no investigation hitherto of the amount and character of such refraction. The chief conclusion of the present section, that irregular refraction is *not* responsible for the greater part of the R−D correction, took me quite by surprise; and as it is just possible that there is some flaw in the argument, I have preferred to accept the entire responsibility of the section.

25. It was shown in a recent paper (*Monthly Notices*, vol. liii. p. 424) that the excess of internal temperature over external was large on occasions when the external temperature was below the average, and small when above the average; and it is concluded that any phenomenon (such as the R−D discordance) which originated in the unequal heating of the air inside the room should vary accordingly. As a rough numerical approximation, it was found that such a phenomenon *should disappear when the external temperature is about* 13° *above the average, and be doubled when the temperature is about* 13° *below the average.*

26. If we conceive isothermal surfaces drawn surrounding the instrument for every tenth of a degree Fahrenheit, then when the external temperature is below the average these surfaces will be numerous and closely packed; when above the average they will be few and more widely separated If the forms of the surfaces are the same in the two cases, then irregular refraction will vary as the number of surfaces cut by the ray. But it is probable that the forms will also change to some extent, as the external temperature rises and falls; and a complete discussion of any phenomenon known to depend on these surfaces would necessarily include an investigation

of the forms and changes of form of these surfaces. But for the present purpose no such investigation is necessary. It would seem conclusive that a phenomenon which remains the same for temperatures *above* and *below* the average cannot depend on these surfaces which are known to change, certainly in number, and probably in form, as the temperature rises above or falls below the average.

If, then, we find that the R−D discordance is sensibly the same at temperatures above and below the average, it seems almost certain that we cannot look to the unequal heating of the strata of air surrounding the instrument to explain it.

27. The years 1884–1891 were selected for examination on this point. By reference to the meteorological section of the Greenwich volumes, lists of dates were prepared for each year in which the temperature was *considerably* above or below the average; and the reflexion observations of stars observed on these dates were then taken from the section where they are tabulated, together with the actual external temperature at the time of observation, as given in the section of Zenith Distances. These temperatures were compared with the mean temperature for that day of the year as given in Mr. Ellis's paper "The Mean Temperature of the Air on each Day of the Year at the Royal Observatory, Greenwich, on the Average of the Fifty Years 1841 to 1890" (*Quart. Journ. R. Met. Soc.*, vol. xviii. No. 84), and the mean deviations from the average were found to be as below:

Year.	Mean Excess of Temperature above the average at Observation by Reflexion of			
	North Stars.		*South Stars.*	
	+	−	+	−
1884	3°·85	8°·68	4°·52	8°·30
1885	4·73	10·13	5·20	8·17
1886	5·68	9·15	6·15	8·03
1887	2·81	8·89	3·69	8·58
1888	3·86	9·13	4·26	8·84
1889	2·68	6·06	4·06	5·97
1890	4·55	9·87	4·65	8·75
1891	3·66	8·78	4·35	9·12
Mean	+3·94	− 8·87	+4·61	−8·22

Since reflexion observations are made at night, when the temperature is below the daily average, the mean value of the positive column is less than that of the negative column.

28. Now suppose that at a given Z.D. the part of the R−D discordance depending on abnormal refraction by the heated air round the instrument is r; the total R−D being R+r; and let r_0 be the mean value of r. Then when the external temperature is 13° above the average r=0, and when 13° below the average $r = 2r_0$; or generally if E° be the excess of external temperature above the average

$$r=r_0\left(1-\frac{E}{13}\right).$$

Thus for our stars selected as being observed on warm nights we should have about

$$r_1=r_0\left(1-\frac{4\cdot3}{13}\right)=r_0\times0\cdot7,$$

and for those on cold nights

$$r_2=r_0\left(1+\frac{8\cdot5}{13}\right)=r_0\times1\cdot7.$$

Thus R+r_1 and R+r_2 being the mean values of the whole R−D in the two cases

$$(R+r_2)-(R+r_1)=r_2-r_1=r_0\times1\cdot0,$$

or the difference between the two values of R−D should be approximately equal to the part of the R−D which depends on abnormal refraction.

29. The results of R−D were arranged in groups of 10° of N.P.D., viz., N.P.D. −30° to −20°, N.P.D. −20° to −10°, N.P.D. −10° to 0°, N.P.D. 0° to 10°, &c. For brevity the N.P.D. of each group is given at the head of a column, as −25°, −15°, −5°, +5°, &c., although these figures are only approximate. Under each of these headings is given the mean R−D for the group and the number of stars in the group.

TABLE XIII.

Temperature above the Average.

Year.	*North Stars.*									
	N.P.D. –25°.		–15°.		–5°.		+5°.		+15°.	
	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.
1884	+1·60	19	+0·44	5	–0·12	4	–0·42	2	+1·26	7
1885	+1·62	8	+0·74	8	–0·50	1	+1·14	5	–1·34	1
1886	+0·90	8	+2·04	6	+0·70	5	–0·06	3	+0·76	2
1887	+1·34	10	+0·32	6	+0·46	6	+1·04	7	+1·18	10
1888	+0·90	4	+1·06	13	+0·96	6	+0·54	4	+0·02	10
1889	+2·00	2	+1·58	5	+0·70	3	+0·70	6	+0·84	15
1890	+0·84	8	+0·82	4	+0·52	1	+0·14	4	–0·30	9
1891	+0·76	10	+1·52	6	+0·30	8	+0·38	6	–0·08	3

Year.	*South Stars.*									
	N.P.D. 65°.		75°.		85°.		95°.		105°.	
	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.
1884	–0·50	5	–0·02	5	–0·28	12	–1·44	19	–1·20	9
1885	–0·20	6	–0·74	6	–1·44	8	+0·02	5	–1·30	3
1886	–0·36	6	+0·32	4	–0·62	15	–1·80	9	–1·46	5
1887	–0·48	6	–0·60	17	–0·78	13	–1·34	6	–1·76	7
1888	–0·38	9	–0·22	11	–1·32	10	–1·62	2	–0·66	3
1889	–0·52	10	–0·14	9	–0·02	5	–1·42	6	–1·40	2
1890	–0·14	5	–0·02	11	–0·54	7	–0·72	4	–0·96	3
1891	–0·24	9	–0·98	12	–0·42	8	–0·70	9	–1·50	2

TABLE XIII.—(*continued*).

Temperature below the Average.

Year.	*North Stars.*									
	N.P.D. −25°.		−15°.		−5°.		+5°.		+15°.	
	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.
1884	+1·04	6	−0·06	1	...	...	...	...	+0·12	4
1885	+0·88	19	+1·26	8	+0·76	9	+0·52	9	+0·28	11
1886	+1·48	14	+1·32	13	+0·62	8	+0·54	4	+0·36	5
1887	+1·26	20	+0·40	10	+0·98	6	+0·62	19	+0·80	18
1888	+1·12	13	+1·70	16	+0·60	14	+0·30	11	+1·12	6
1889	+2·46	9	+0·74	6	+0·30	8	+0·36	11	+0·56	6
1890	+2·42	4	+1·48	11	+0·88	8	+1·16	10	+0·20	6
1891	+1·10	13	+0·62	16	+0·30	7	0·00	6	+1·22	3

Year.	*South Stars.*									
	N.P.D. 65°.		75°.		85°.		95°.		105°.	
	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.	"	No. Obs.
1884	−0·28	4	+0·50	3	−0·62	3	−2·28	2	−1·56	4
1885	−0·32	14	−0·14	28	−0·82	17	−0·86	12	−1·34	9
1886	+0·18	11	+0·08	15	−0·74	15	−0·64	18	−1·74	7
1887	+0·08	20	−0·30	25	−0·88	22	−0·62	5	−1·30	12
1888	−0·52	17	−0·36	25	−0·82	12	−1·82	15	−1·72	7
1889	+0·34	10	−0·66	11	−0·18	9	−1·20	14	−4·00	2
1890	−0·14	12	−0·44	11	−1·04	12	−0·88	10	−1·98	4
1891	−0·30	8	−0·36	17	−0·48	15	−1·10	9	−1·78	9

30. Forming now the differences "Below—Above," we get for the values of r_0 the quantities below. Weights are assigned according to the formula

$$\frac{2mn}{m+n},$$

where m and n are the numbers of observations in the two groups.

TABLE XIV.

Below—Above.

North Stars.

Year.	N.P.D. −25°.	Wt.	−15°.	Wt.	−5°.	Wt.	+5°.	Wt.	+15°.	Wt.
	″		″		″		″		″	
1884	−0·56	8	−0·50	2	...	...	...	...	−1·14	5
1885	−0·74	11	+0·52	8	+1·26	2	−0·62	6	+1·62	2
1886	+0·58	10	−0·72	8	−0·08	6	+0·60	3	−1·12	3
1887	−0·08	13	+0·08	8	+0·52	6	−0·42	10	−0·38	13
1888	+0·22	6	+0·64	14	−0·36	8	−0·24	6	+1·10	8
1889	+0·46	3	−0·84	15	−0·40	4	−0·34	8	−0·28	9
1890	+1·58	5	+0·66	6	+0·36	2	+1·02	6	+0·50	7
1891	+0·34	11	−0·90	9	0·00	7	−0·38	6	+1·30	4
Mean	+0·10	67	−0·14	70	+0·04	35	−0·14	45	+0·08	51

South Stars.

Year.	N.P.D. 65°.	Wt.	75°.	Wt.	85°.	Wt.	95°.	Wt.	105°.	Wt.
	″		″		″		″		″	
1884	+0·22	4	+0·52	4	−0·34	5	−0·84	4	−0·36	6
1885	−0·12	8	+0·60	10	+0·62	11	−0·88	7	−0·04	5
1886	+0·54	8	−0·24	6	−0·12	15	+1·16	12	−0·28	6
1887	+0·56	9	+0·30	20	−0·10	16	+0·72	5	+0·46	9
1888	−0·14	10	−0·14	15	+0·50	11	−0·20	4	−1·06	4
1889	+0·86	10	−0·52	10	−0·16	7	+0·22	8	−2·60	2
1890	0·00	7	−0·42	11	−0·50	9	−0·16	6	−1·02	3
1891	−0·06	8	+0·62	14	−0·06	10	−0·40	9	−0·28	3
Mean	+0·25	64	+0·10	90	+0·01	84	+0·08	55	−0·35	38

31. It thus appears that only a very small part of the R−D discordance, if any, can be referred to the unequal distribution of temperature near the instrument. The above investigation seems to be conclusive on this point, though I confess to being puzzled by the unexpected result.

The Anomalous Nature of the Direct Observations which follow Reflexion Observations. §§ 32–38.

32. We now come to a different line of investigation. An accident suggested a comparison between the direct observations of zenith distance associated with reflexion observations, and those of the same star not so associated; and a sensible discordance was found between the two. As we have denoted the observations, reflexion and direct, by the letters R and D in what precedes, we shall adopt the letter D_o to denote a direct observation not preceded by a reflexion observation; and the discordance now in question will be called the "DD_o discordance."

33. The years first examined were 1884, 1885, and 1888. It will be sufficient to give the results of this preliminary examination very briefly. The weighted mean excess of a D observation over the mean of the D_o observations of the same star is given in the following table; the + sign indicating that a D observation gives a larger *zenith distance* than a D_o observation.

TABLE XV.

Mean D D′ discordance in the years 1884, 1885, 1888.

North Stars.			*South Stars.*		
Limits of N.P.D.	DD_o.	No. Obs.	Limits of N.P.D.	DD_o.	No. Obs.
+30° to +20°	−0″·04	37	50° to 60°	−0″·16	28
+20 " +10	−0·02	17	60 " 70	−0·22	88
+10 " 0	−0·07	52	70 " 80	−0·19	108
0 " −10	−0·31	43	80 " 90	−0·23	133
−10 " −20	−0·17	24	90 " 100	−0·18	111
−20 " −30	−0·56	58	100 " 110	−0·03	69

The accidental errors are shown by the separate results for each year to be large; and it is probable that the large result for N.P.D. −20° to −30° is

due to accidental causes. On the south of the zenith, where more observations are available, the discordance remains nearly constant at all zenith distances. In the next few paragraphs the investigation is confined for simplicity to South Stars between N.P.D. 60° and 100°, and it is assumed that the DD_0 discordance remains practically constant between these limits.

34. Next the ledgers of the nine years 1884 to 1892 were examined. Each D observation was separately compared with the mean of all the D_0 observations of the same star in the same year, and the excess was entered under the month of the year in which the D observation was made. The whole period of nine years was divided into two, and the results are given in Table XVI.

TABLE XVI.

DD_0 discordance for each month of the years 1884–1892.

	1884–88.	1889–92.	Whole Period.		1884–88.	1889–92.	Whole Period.
Jan.	−0″48	−0″29	−0″38	July	−0″52	−0″50	−0″51
Feb.	−0·44	−0·41	−0·43	Aug.	−0·20	−0·27	−0·22
Mar.	+0·24	−0·33	+0·02	Sept.	−0·23	−0·25	−0·23
Apr.	−0·24	−0·22	−0·23	Oct.	−0·28	−0·56	−0·41
May	−0·52	−0·16	−0·35	Nov.	−0·24	−0·38	−0·29
June	−0·36	−0·53	−0·43	Dec.	−0·20	−0·29	−0·23

35. The second period was examined to see whether the curious drop in March, shown by the period 1884–88, was confirmed. As no confirmation was forthcoming, the whole series was arranged in sequence, and means taken for every five months, as below.

TABLE XVII.

1884	Jan. to May	−0″20	1886	Dec. to April	−0″25	1889	Nov. to Mar.	+0″15
	June „ Oct.	+0·19	1887	May „ Sept.	−0·36	1890	Apr. „ Aug.	+0·18
	Nov. „ Mar.	+0·02		Oct. „ Feb.	−0·39		Sept. „ Jan.	−0·79
1885	Apr. „ Aug.	+0·14	1888	Mar. „ July	0·00	1891	Feb. „ June	−0·61
	Sept. „ Jan.	+0·54		Aug. „ Dec.	+0·05		July „ Nov.	−0·17
1886	Feb. „ June	+0·46	1889	Jan. „ May	+0·21	1892	Dec. „ Apr.	−0·08
	July „ Nov.	−0·05		June „ Oct.	+0·31		May „ Sept.	+0·05

36. This series of values at different times seemed very puzzling, but an examination of the observations near the dates where the changes were most abrupt (especially in 1886 and 1890) revealed the cause of the discrepancies in an erroneous value for the adopted inclination of the horizontal wire of the telescope micrometer. It was remarked in § 5 that the D observations are all made *after* the meridian, whereas the D_o observations should be made *on* the meridian. Hence if the inclination of the wire is not rightly determined, there will be a systematic difference between D and D_o.

37. The inclination of the wire for some years back had recently been recomputed from the observations; and it was easy to compare the error of adopted inclination with the above results. It was at once seen that the fluctuations in the DD_o discordance could be thus explained. More particularly the abrupt changes in 1886 and 1890 were explained by the removal of the wire frame in those years to insert a new wire, without a new determination of the inclination having been properly made.

38. In order to allow for the effect of error in adopted inclination, we must determine by how much on the average a D observation is subsequent to a D_o. An examination of two years' observations 1889 to 1890 was considered sufficient for this purpose, and the result was found to be about three wire intervals ($=10'$ about).

39. We are now in a position to give the true DD_o discordance independent of the error in adopted inclination of the horizontal wire. The results are given as before for periods of five months, but are carried over thirteen years—from the beginning of 1880 to the end of 1892. The mean epoch of each group of five months is given approximately in decimals of a year.

TABLE XVIII.

DD_0 Discordance corrected for Error in Inclination.

Epoch.	DD_0	Epoch.	DD_0
1880·2	$-0''\!\cdot\!25$	1886·0	$+0''\!\cdot\!15$
80·6	− ·23	86·5	− ·23
81·0	− ·09	86·9	− ·28
81·5	+ ·01	87·3	− ·28
81·9	− ·28	87·7	− ·49
82·3	− ·30	88·1	− ·27
82·7	− ·34	88·5	− ·27
83·1	− ·12	89·0	− ·38
83·5	− ·25	89·4	− ·11
84·0	− ·54	89·8	− ·26
84·4	− ·47	90·2	− ·20
84·8	− ·08	90·6	− ·35
85·2	− ·30	91·0	− ·85
1885·6	− ·20	1891·5	− ·53

The mean result is $-0''\!\cdot\!27$, and the variations still remaining may be regarded as due to accidental causes.

40. With respect to the above error in inclination and its effect on the R − D discordance, it should be remarked that if the R and D observations are made at equal distances from the meridian, the R − D discordance will not be affected by an error in adopted inclination ; but *both* the observations of zenith distance will be equally in error. If they are not made at *equal* distances from the meridian, but still on opposite sides of it, the effect on the R − D will still be small.

41. It thus appears that a zenith distance given by a D observation is $0''\!\cdot\!27$ less than a zenith distance of the same star given by a D_0 observation. Does this mean that the telescope or some part of it does not take up a new position all at once, but slowly settles into it for some minutes after setting ? If so, it would be easy to understand how a D observation which is made immediately after setting the instrument differs from a D_0 observation made

more at leisure, though the intervals from setting to the observation cannot differ by more than about one minute of time. Further, the previous position of the instrument is different in the two cases: for the D observation the telescope has just been pointing downwards; for the D_0 observation it has probably just previously been pointing upwards to another star, or nearly horizontally, to have the punctures read from the recording micrometer.

42. Several obvious experiments were made in the light of these suggestions without result. But a series of the first importance for the present investigation was more fortunate. It was determined to try the effect of *reversing the order* of the R and D observations, and taking the D observation first. Observations were made of one hundred and seventeen stars on eleven nights, as in Table XIX., in which column 1 gives the date, column 2 the number of stars, column 3 the observed R−D, and column 4 the computed R−D, supposing the observations to be made in the ordinary way.

TABLE XIX.

Date.	No. Obs.	R−D.	
		Observed.	Computed.
		″	″
1893 Dec. 3	16	−0·54	+0·79
8	10	−0·81	+0·87
21	8	+0·09	+0·92
1894 Jan. 8	5	−0·20	+0·84
9	19	−0·39	+0·93
11	5	−1·35	+0·73
Feb. 21	4	+0·28	+0·79
Mar. 4	12	+0·12	+0·80
17	11	−0·95	+0·95
Apr. 6	8	−0·52	+0·85
22	19	+0·33	+0·86
	Total 117	Mean −0·32	+0·81

43. It thus appears that this change of order in the observation *reverses the sign of the R–D discordance.* The discordance is in fact intimately bound up with the history of the instrument in the few minutes before the observation is made, and during the time it is proceeding. This raises a number of questions the settlement of which must be left to future investigations. Though the problem of the R–D discordance is by no means solved, yet the investigation has been brought to a definite stage, beyond which it does not appear probable that the present investigators can proceed immediately; and it has therefore been considered advisable to publish these results as they stand.

On the Rotation and Mechanical State of the Sun. By R. A. Sampson, M.A.,
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No mathematician can have studied the writings that explain the rotation of the Sun without feeling that the problem has never been fairly essayed with the machinery which he possesses; and that the general arguments upon which the writers rely are incapable of showing the sufficiency of any one of the causes assigned, of fully exposing the consequences of its assumptions, and even in some cases of so much as demonstrating its existence.

Now one assumption of any theory is an internal state agreeable to the action of the cause assigned. Hence we may succeed in proving a cause to be sufficient and to involve no improbabilities, but we cannot show it to be necessary.

Now it appeared to me, on such general grounds as are explained in Part II., § 1, that the observed motion was susceptible of explanation without other assumptions as to the internal state than that of an angular motion increasing inwards along all radii and a fluid constitution which was solicited, as all fluids must be, by internal friction. Accordingly I attempted the task of examining as completely as possible the consequences implied by ascribing the observed superficial motion to such causes, with the results exposed in the following pages.

After proceeding a certain way with the theory of the Sun's rotation, it became evident that no conclusion could be reached without a satisfactory theory of the distribution of his internal temperature. With the existing

theory of convective equilibrium I felt dissatisfied; accordingly I attempted the discussion of the distribution of temperature by radiation and absorption, and arrived at a theory which is explained in Part I., § 3. I feel that this theory should hardly form part of a serious essay without some manner of apology. Radiation and absorption are a subject for theories concerning the mutual relations of matter and ether, but these theories are not in such a state as to assist my purpose, which, though important, is subsidiary. Therefore I construct certain hypotheses as to the manner of action of radiation and absorption, which are designed to retain what seems most essential, while leaving such simplicity of form as will permit me to deduce conclusions; in short, to parody a great saying, *hypotheses fingo*. This will condemn that part of my work as an ultimate theory, if indeed any can be so called; but perhaps it will be held provisionally to throw some light upon a region otherwise wholly dark.

PART I.

THE MECHANICAL STATE OF THE SUN.

§ 1. *General.*

Let p, ρ, θ denote respectively pressure, density, and absolute temperature at any point of a gas, and let them be bound by the relation

$$p=\kappa\rho\theta \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where κ is a constant.

If there is equilibrium

$$-\frac{1}{\rho}\frac{dp}{dx}+X=0$$

$$-\frac{1}{\rho}\frac{dp}{dy}+Y=0;$$

$$-\frac{1}{\rho}\frac{dp}{dz}+Z=0;$$

where X, Y, Z are applied forces per unit mass at x, y, z. Hence if the gas is at rest under gravitation

$$dp=\rho dV \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where V is the gravitational potential at the point considered of the whole gas and of any other attracting matter there may be.

The law that governs the temperature will supply a third equation; in general θ will not be a function of ρ alone.

If θ is not a function of ρ alone, the solution of these equations is of a character that cannot bear the proposed physical interpretation, and we conclude that they rest upon a false assumption; in other words, equilibrium in a gas is an exceptional state, and generally the level surfaces of pressure, density, temperature, and potential in a gas will differ from one another and will be in continual motion.* And clearly the general exceptions are these, (1) when the equilibrium is maintained from without by some agency which renders θ a function of ρ alone, including the case of a uniform temperature; (2) when the geometry requires all quantities to be functions of a single parameter.

In either of these cases the state of equilibrium which is given by solution of the equations must be scrutinised to see if it be stable.

§ 2. *Forced Equilibrium.*

Let us briefly consider the first of these exceptional cases. We have

$$\nabla^2 V = -4\pi\rho.$$

Hence writing $\rho = f(V)$, the problem is expressed by the equation

$$\nabla^2 V = -4\pi f(V)$$

Hence we may deduce that in the presence of any attracting masses, a gas can be distributed so as to lie with any given density at every point of any prescribed surfaces. For let

$$V = V_1 + V_2,$$

where

$$\nabla^2 V_1 = 0,$$

while V_2 is a particular solution of

$$\nabla^2 V_2 = -4\pi f(V_1 + V_2),$$

and express the values of V_1 and V_2 over the prescribed surfaces by (1) and

* It is worth remarking that this is one of the causes producing motion in the atmosphere; it differs from other causes, such as the Sun's radiation, the Earth's radiation, the Earth's figure and motion, the attraction of the Sun and Moon, in being more anomalous, and it may perhaps be an important factor in the anomalies of climate.

(2). Then it is required to make (1) + (2) of given value. But (2) depends wholly upon (1). Hence it is required that (1) shall be of arbitrarily given value. But this is possible.

Let us now investigate the circumstances under which a finite quantity of gas, not circumscribed by artificial boundaries, will occupy a finite space. To discuss this question, we first prove the following analytical lemma.

The necessary and sufficient condition for the convergency of the integral $\mathrm{I} = \int^{\infty} y\,dx$ *is that* $\mathrm{Lt}\; yx \,.\, \log x \,.\, \log\log x \,.\,.\,.\,.\,.\, \log\log \,.\,.\,.\, \log x$ *shall be zero when* $x = \infty$, *where the last factor is finite.* For taking $x = n$ in place of $x = \infty$, a part of the remainder is

$$\int_n^{sn} y\,dx$$

$$> y_{sn}(sn - n),$$

where s is as great as we please. Hence in order that the integral may be convergent, we must have

$$yx = y_1,$$

where

$$\underset{x=\infty}{\mathrm{Lt}}\, y_1 = 0.$$

Now writing

$$\mathrm{I} = \int^{\infty} y_1 \frac{dx}{x},$$

similar reasoning proves

$$y_1 \log x = y_2,$$

where

$$\underset{x=\infty}{\mathrm{Lt}}\, y_2 = 0.$$

Therefore

$$\mathrm{I} = \int^{\infty} y_2\,dx/x \log x\;;$$

whence

$$y_2 \,.\, \log\log x = y_3,$$

where

$$\underset{x=\infty}{\mathrm{Lt}}\, y_3 = 0\;;$$

and we proceed thus until the ratio $y_r : y_{r+1}$ is finite. Hence the condition is necessary. To show that it is also sufficient, we merely observe y is infinitely less than

$$\frac{d}{dx}(\log\log \ldots\ldots \log x),$$

so that the remainder above is less than any finite multiple, however small, of log log . . . log x, which, by hypothesis, is finite.

We may deduce without difficulty that the condition is fulfilled if y at infinity $\propto x^{-1-p}$, where p is any finite positive quantity, however small. For denoting the finite value of log log . . . log x by z, and e^z, e^{e^z}, &c., by $e_1(z)$, $e_2(z)$, &c., the logarithm of the multiplier of y is

$$z+e_1(z)+e_2(z)+\ \ldots\ +e_{n-1}(z)+e_n(z),$$

where n is the number of factors, infinite for infinite x, or

$$e_n(z)\left[1+\frac{e_{n-1}(z)}{e_n(z)}+\frac{e_{n-1}(z)}{e_n(z)}\,\frac{e_{n-2}(z)}{e_{n-1}(z)}+\ \ldots\ +\frac{e_{n-1}(z)}{e_n(z)}\ \ldots\ \frac{z}{e_1(z)}\right]$$

that is

$$e_n(z)(1+\epsilon),$$

where ϵ is infinitely small, being infinitely less than the geometrical progression to infinity, of which the common ratio is $z/e_1(z)$. But the logarithm of y is

$$-e_n(z)(1+p),$$

where p is finite. Hence the sum is $-\infty$, or in other words

$$\underset{x=\infty}{\mathrm{Lt}}\, yx \,.\, \log x \,.\, \log\log x \ldots \log\log \ldots \log x=0.$$

Returning to the question in hand, we have

$$V=\kappa\int\theta dp/p+C.$$

But for a finite body the potential function on the left is finite. Hence on the right, either the range of pressure from zero upwards is infinitely small or else, as p decreases to zero, the rate of decrease of θ makes

$$\underset{p=0}{\mathrm{Lt}}\,\theta \,.\, \log\frac{1}{p} \,.\, \log\log\frac{1}{p} \ldots\ldots \log\log \ldots \log\frac{1}{p}=0,$$

the last factor being finite. The former case is that of a finite body of gas infinitely diffuse at all points; the latter is that of a finite body cohering in a finite space.

When the temperature condition above is unfulfilled, and therefore the gas extends to infinity, an infinite mass is required in order that the density and pressure at any point may be finite. This immediately follows from the non-convergence of the value of V when the limits of p on the right are

separated by a finite interval. But as the theorem is of considerable interest, let us consider it in a case where we can follow its details more closely. Let θ be constant. We then have * from p. 3

$$\nabla^2 \log \rho + 4\pi\rho/k = 0,$$

where

$$p = k\rho.$$

Let

$$\log \rho = f(\log r, \theta, \phi)$$

be any solution of this, r, θ, ϕ being ordinary polar coordinates; then we observe that

$$\log \rho - 2c = f(\log r + c, \theta, \phi),$$

where c is an arbitrary constant, is also a solution. Now it happens that we can derive a singular solution from this form; for differentiating with respect to c, we get $\log r + c =$ a function of θ and ϕ. Whence the singular solution

$$\rho = r^{-2}\mathrm{F}(\theta, \phi).$$

Consider the distributions of density which are finite in parts, but diminish to zero at infinity. $\rho = 0$, $r = \infty$ satisfy simultaneously these and the above found singular solution; hence the singular solution is asymptotic to such distributions, and it shows that the density diminishes proportionally with r^{-2}, where infinitely remote from finite condensations. Whence we immediately conclude that the whole mass is infinite.†

§ 3. *Law of Temperature.*

The last section, treating of equilibrium artificially produced, is to some extent a digression, and we now return to consider the distribution of temperature by natural means.

There are two means by which temperature is distributed—conduction and radiation. In the diffuse structure of a gas the former is virtually

* *Cf.* G. W. Hill, *Annals of Mathematics*, 1888, vol. iv. p. 19.

† Discussion of constant temperature distributions in spheres will be found in the following papers:—Ritter, *Wiedemann's Annalen*, 1882, N.F., Bd. xvi. p. 166 *et passim.* Hill, *l.c.* Darwin, *Phil. Trans.*, 1889, vol. clxxx. p. 1.

inoperative, unless some external cause such as statical instability mingles systematically the parts whose temperatures differ most. Hence we must attempt a discussion of radiation.

We are without that knowledge of the interaction of matter and ether upon which a theory of radiation must ultimately rest. That theory which I now put forward may be regarded as a caricature in mathematics of these half known relations ; but perhaps the reader will admit what the writer holds, that it preserves, although imperfectly, the features that are essential.

Let us confine attention to radiations of a single wave-length.

Let us assume that *the energy lost in radiation per unit time by a small isolated body of gas is proportional to the temperature and the mass conjointly.*

That is, the rate of loss of energy of a molecule by radiation is proportional to the energy of vibration it possesses, and the energy of vibration is a constant fraction of its total energy. The latter part is an extension from the well-known assumption of the kinetic theory of gases that the energy of translation is a constant fraction of the whole. If we suppose the molecules of the nature of elastic bodies, and their vibrations maintained by impacts, the average energy of translation will be proportional to the average energy of vibration, and, apart from other physical characters ascribed to the molecules, to this alone, for it will be independent of the actual number of the impacts if these are frequent enough to obliterate one another's individual effects. The actual proportions of the division of energy between translation, rotation, and vibration depend upon the physical nature ascribed to the molecules ; they may perhaps be the same for different gases ; on the other hand, it may conceivably be necessary to adopt a structure for which the assumption is untrue.

Secondly, assume *the energy absorbed per unit time by a small portion of gas is proportional conjointly to the mass of the gas and to the whole energy of the radiations that penetrate it.*

I view this assumption thus : If a number of systems vibrating in the same period be agitated by a periodic disturbance of like period and of constant amplitude, then, allowing for difference of phase, the average effect in unit time will be an increase of the squares of the amplitudes of the vibrating systems by a quantity proportional to the square of the amplitude of the disturbance. Hence the average rate of increase of the energy of a molecule per unit time will be proportional to the square of the amplitude of the vibrations

that are carried past it, and it will also be proportional to the inertia of the quantity of ether that carries these vibrations. Summing the absorptions for all the molecules in the quantity of gas considered, we arrive at the above assumption.

Let a thin sheet of gas, forming a closed surface, emit heat for an instant dt; and let us consider the nature of the agitation subsequently produced at any point of the medium in which it is.

Divide the sheet into a doubly infinite number of elements, each possessed of an equal amount of heat, and therefore each radiating an equal quantity of energy in the instant dt. Let us suppose the medium to refract the radiations, but let us leave its absorption out of view for the present, and trace for each element the surfaces which its radiations would have reached in times t and $t + dt$ respectively.

The envelopes of these two surfaces for all elements of the emitting sheet will enclose between them a sheet, all points of which will be simultaneously and for the first time agitated by the emissions from the different elements. Consider now what will follow the first agitation that reaches any point; at each subsequent instant it will be attacked by agitations proceeding from rings of elements surrounding the first element, until at length it has received agitations from all elements of the emitting sheet, and no more reach it.

Now suppose the original emissions not to cease after an instant dt, but to be maintained for a finite time. Then we know by considerations fundamental to the undulatory theory of light that the joint effect of all the disturbances which reach a certain point P at any instant is one half that sent out from a circle on the emitting sheet whose centre Q is the point nearest to P in respect to time, and whose circumference is half a wave-length more distant. In this joint disturbance the contribution of each element might be traced; as, for example, an eye placed at P could see each element of a luminous body whence it received light; but for the sake of simplicity I make the third and final assumption that the entire disturbance at P is due to Q; in other words, that *the entire radiations from each element of a radiating sheet pursue the same course without interference*; so that, tracing the lines from the outline of any element along which the foremost radiations pass, we obtain a tube within which I suppose the entire radiations that take place between the times t and $t + dt$ to remain perpetually. It does not appear that this assump-

tion can sensibly affect the distribution of temperature in such systems as I wish to discuss, where the emissions are maintained unchanged throughout long periods, and the absorbing body is so dense as to stifle them within a short distance of their source.

From this point of view let us consider the transmissions of radiations by a number of sheets which partly transmit, partly reflect, the energy that falls upon them. Consider two elements upon two of these sheets as radiating energy towards each other, which is in part lost and scattered in the course. Let the element of the first sheet be emitting a quantity of energy E per unit time, and let it absorb a fraction A of the energy which falls upon it. Let E′, A′ refer to the element of the second sheet. Let the fraction k be lost to other sheets by absorption and reflection taking place along the path in question. The fraction k will be the same, in whichever sense the path is followed; so that the element of the second sheet receives from the first $(1-k)$ EA′, and the first receives from the second $(1-k)$ E′A. Now if the temperature were constant throughout the system, radiation would produce no disturbance of it. But this cannot be unless these two amounts are the same at the same temperature for sheets of every description of matter, and for every wave-length and manner of polarisation; or E : A is a function of the temperature and wave-length alone, and is independent of the nature of the matter. And this theorem is still true when the sheets emit simultaneously rays of various wave-lengths.* For the first sheet may be replaced by another which emits the different rays in proportions arbitrarily different, and the equilibrium will not be disturbed thereby. But this cannot be, unless for each wave-length there is a ratio E : A independent of the nature of the matter.

Let us now consider a body of gas of finite dimensions which emits radiations from all its parts for a single instant. Let us examine how we may simplify the effects in accordance with the geometrical assumption we have just made. Let the body be divided into a triply infinite number of elements, each possessed of equal heat, and let any family of surfaces be drawn through these elements. Then the whole radiations may be viewed as the sum of the waves emitted by the several members of this family after the manner just considered. For families in general these waves would overlap, and become confused with one another, and no clear resultant wave would emerge. But

* *Cf.* Kirchhoff, *Phil. Mag.*, 1860 July (translated by Stokes).

there is a single family such that no confusion or overlapping occurs. This family consists of those surfaces with which a wave would successively coincide, which initially coincided with the bounding surface and proceeded inwards. If the body of gas be divided into sheets by these surfaces, the emissions from one of these sheets between the times t, $t + dt$ will be found entire (ignoring absorption) at any subsequent instant within another sheet of the series. Now consider the effect of absorption upon the elements of equal heat which compose any one of these sheets. Each element absorbs in proportion to its mass ; therefore unless the elements of equal heat are also elements of equal mass, their quantities of heat will become different in consequence of absorption. That is to say, the sheets must be surfaces of equal temperature, or else the surfaces of equal temperature will be in continual change. The latter will be the general case ; but there are obvious and very important exceptions, namely, when all quantities are geometrically functions of a single parameter. This includes distributions which are uniform with respect to infinite planes, infinite circular cylinders, or spheres.

Let us now discuss the distribution of temperature in these exceptional cases, and in accordance with our assumptions write

$$E = \varpi dm\theta, \qquad A = \varpi' dm,$$

where E, A refer to entire sheets, E being the rate of emission of energy per unit time from the sheet in either direction, and A the fraction absorbed of the energy that penetrates the sheet ; θ is the temperature, ϖ and ϖ' are constants depending upon the nature of the matter and upon the wave-length alone, while $\varpi : \varpi'$ is independent of the former, all the quantities being, by hypothesis, the same throughout the sheet. And it now appears that the arbitrary part of our first two assumptions is expressed in taking E : A proportional to the temperature, whereas the manner in which it involves the temperature as well as the wave-length is unknown.

Since all quantities are functions of one parameter, it is competent to take any one of them for independent variable ; it will be convenient to take mass. Let $m = m_0$ and $m = m_1$ be the boundaries.

The amount of energy radiated from the sheet dm in both directions per unit time is

$$2\varpi dm\theta,$$

and the part of this which reaches another sheet, m', is

$$\varpi dm\theta(1-\varpi' dm)^{\frac{m'-m}{dm}}=e^{-\varpi'(m'\sim m)}\varpi dm\theta.$$

Conversely, the gain of energy of the layer dm by absorption is

$$\varpi' dm\int_{m_0}^{m} e^{-\varpi'(m-m')}\varpi dm'\theta'+\varpi' dm\int_{m}^{m_1} e^{-\varpi'(m'-m)}\varpi dm'\theta'.$$

Hence if we write the rate of loss of energy of dm

$$-cdm\frac{d\theta}{dt},$$

where c may be supposed a constant, we have

$$-c\frac{d\theta}{dt}=2\varpi\theta-\varpi\varpi' e^{-\varpi' m}\left[\int^{m} e^{\varpi' m'}\theta' dm'-\text{A}\right]$$

$$-\varpi\varpi' e^{\varpi' m}\left[\text{B}-\int^{m} e^{-\varpi' m'}\theta' dm'\right],$$

where

$$\text{A}=\int^{m_0} e^{\varpi' m'}\theta' dm';$$

$$\text{B}=\int^{m_1} e^{-\varpi' m'}\theta' dm'.$$

Hence

$$-\frac{1}{\varpi\varpi'}\left[c\frac{d\theta}{dt}+2\varpi\theta\right]=\text{A}e^{-\varpi' m}-\text{B}e^{\varpi' m}+2\int^{m}\sinh\varpi'(m-m')\,\theta' dm' \quad \ldots \quad (1)$$

But it is well known that the right-hand member is a solution of the equation

$$\frac{d^2z}{dm^2}-\varpi'^2 z=2\varpi'\theta.$$

Hence θ satisfies the equation

$$\left(\frac{d^2}{dm^2}-\varpi'^2\right)c\frac{d\theta}{dt}+2\varpi\frac{d^2\theta}{dm^2}=0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

But we must remember that the equation that actually determines it is the less general form above involving A and B; so that, if we prefer to solve it under the form (2), we must afterwards adapt two of the arbitraries of the solution to the known values of A, B, that is, to the circumstances at the boundaries.

Assume as a solution of (2)

$$\theta=\Sigma\theta_n\cos(\mu_n m+\epsilon_n) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where θ_n is a function of t alone; then

$$\theta_n = a_n \exp.\left(-\frac{2\varpi\mu_n^2}{\mu_n^2+\varpi'^2}\frac{t}{c}\right),$$

where a_n is a constant.

Substitute this element of the value of θ in equation (1); we get

$$-\frac{1}{\varpi\varpi'}\left[-\frac{2\varpi\mu_n^2}{\mu_n^2+\varpi'^2}+2\varpi\right]\theta_n\cos(\mu_n m+\epsilon_n)$$

$$=\mathrm{A}e^{-\varpi' m}-\mathrm{B}e^{\varpi' m}-\frac{2\varpi'}{\mu_n^2+\varpi'^2}\theta_n\cos(\mu_n m+\epsilon_n).$$

Hence the equation is satisfied if we put

$$\mathrm{A}=0,\qquad \mathrm{B}=0.$$

But

$$\mathrm{A}=e^{\varpi' m_0}\theta_n\frac{\varpi'\cos(\mu_n m_0+\epsilon_n)+\mu_n\sin(\mu_n m_0+\epsilon_n)}{\mu_n^2+\varpi'^2};$$

$$\mathrm{B}=e^{-\varpi' m_1}\theta_n\frac{-\varpi'\cos(\mu_n m_1+\epsilon_n)+\mu_n\sin(\mu_n m_1+\epsilon_n)}{\mu_n^2+\varpi'^2}.$$

Hence μ, ϵ are restricted to the singly infinite series of pairs of values which make $\mathrm{A}=0$, $\mathrm{B}=0$; that is to say

$$\epsilon=-\frac{\mu}{2}(m_1+m_0),$$

where μ is a solution of

$$\mu\tan\mu\mathrm{M}=\varpi' \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (4)$$

writing $2\mathrm{M}$ for m_1-m_0, the whole mass. We observe that $\epsilon=0$ if the origin of m pass through the C.G. We shall assume it so taken. Each element of the expression for the temperature, *e.g.*,

$$a_n\exp.\left(-\frac{2\varpi\mu_n^2}{\mu_n^2+\varpi'^2}\frac{t}{c}\right)\cos\mu_n m$$

dies away at a rate peculiar to itself which increases with n, but for no element exceeds a finite limit; and for each element the ratio of the temperatures at different points of the body is the same for all time.

The manner in which the functions $\cos\mu_n m$ arise is a proof from a physical point of view that an arbitrary function $f(m)$ which is taken to represent the initial state of temperature at all points can be expressed by the

development $\Sigma\ \alpha_n \cos \mu_n\, m$; and the coefficients α_n can be readily determined ; for multiply by $\cos\ \mu_n m$ and integrate from $m = 0$ to $m = \mathrm{M}$.
But

$$\int_0^{\mathrm{M}} \cos\ \mu_r m \cos\ \mu_s m dm$$

$$= \frac{\sin(\mu_r + \mu_s)\mathrm{M}}{\mu_r + \mu_s} + \frac{\sin(\mu_r - \mu_s)\mathrm{M}}{\mu_r - \mu_s}\ ;$$

and when $\mu_r \neq \mu_s$, this vanishes by virtue of the relation

$$\mu_r \tan \mu_r \mathrm{M} = \mu_s \tan \mu_s \mathrm{M}.$$

Whence

$$\alpha_n\, \mu_n \left(\mathrm{M} + \frac{\sin^2 \mu_n \mathrm{M}}{\varpi'}\right) = \int_0^{\mathrm{M}} f(m) \cos\ \mu_n m dm.$$

We conclude from the foregoing that for any body to which our theory applies, there is a singly infinite number of rates of cooling, each permanent in its relative temperatures, and each corresponding to different initial arrangements of temperature ; and for an arbitrary initial arrangement, the final mode of cooling will always be the same, namely, the slowest mode, the others having relatively extinguished themselves.

If heat were supplied from external sources arbitrarily throughout the mass (for example, by internal friction), a known function of m and t must be added to the left-hand member of equation (1), and a corresponding term to the right of (2). The value of θ would consist of the complementary function as above, together with a certain particular integral depending upon the rate of supply ; but the equation could not be satisfied unless A and B were increased by appropriate terms expressing external supply of heat at the boundaries.

The whole quantity of heat radiated per unit time from the mass, derived from the element of temperature $\theta_n \cos \mu_n\, m$

$$-\int_{-\mathrm{M}}^{\mathrm{M}} c \frac{d}{dt}(\theta_n \cos\ \mu_n m)\, dm$$

$$= 2\, \frac{2\varpi\mu_n^2}{\mu_n^2 + \varpi'^2}\, \theta_n \frac{\sin \mu_n \mathrm{M}}{\mu_n}$$

$$= 4\, \frac{\varpi}{\varpi'}\, \theta_n^{(1)} \sin^2 \mu_n \mathrm{M} \cos \mu_n \mathrm{M} = 4\, \frac{\varpi}{\varpi'} \theta_n^{(0)} \sin^2 \mu_n \mathrm{M},$$

where $\theta_n^{(1)}$ and $\theta_n^{(0)}$ are respectively the corresponding central and surface temperatures. In this expression the nature of the body enters only through the factors, $\sin^2\mu_n M$ and $\sin^2\mu_n M \cos\mu_n M$.

Let us next consider the values of the quantities μ. Writing

$$\mu_1 M = x, \quad \varpi' M = a,$$

we must solve the equation (4) in the form

$$x \tan x = a \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4a)$$

where a is positive.

Consider first the least root, for different values of a.

1. Let a be less than $\frac{\pi}{4}$, and write $x = \tan^{-1} z$; then

$$z^2 - \frac{z^4}{3} + \frac{z^6}{5} - \ldots\ldots = a,$$

whence

$$z^2 = a + \frac{1}{3}a^2 + \frac{1}{45}a^3 - \frac{1}{189}a^4 + \frac{11}{14175}a^5 \ldots$$

and

$$z = a^{\frac{1}{2}}\left[1 + \frac{1}{6}a - \frac{1}{360}a^2 - \frac{11}{5040}a^3 - \frac{19}{1814400}a^4 \ldots\ldots\right]$$

2. Let

$$a = \frac{\pi}{4};$$

then

$$x = \frac{\pi}{4}.$$

3. Let a be greater than $\frac{\pi}{4}$. Write

$$x = \frac{\pi}{2} - \tan^{-1} z;$$

then

$$\left(\frac{\pi}{2} - \tan^{-1} z\right)\frac{1}{z} = a,$$

or

$$(a+1)z - \frac{z^3}{3} + \frac{z^5}{5} - \ldots\ldots = \frac{\pi}{2},$$

whence

$$z = \frac{\pi/2}{a+1} + \frac{1}{3(a+1)}\left(\frac{\pi/2}{a+1}\right)^3 - \frac{3a-2}{15(a+1)^2}\left(\frac{\pi/2}{a+1}\right)^5 + \frac{45a^2 - 78a + 17}{315(a+1)^3}\left(\frac{\pi/2}{a+1}\right)^7 \ldots$$

The following table is derived from these results, and expresses the relations of a or $\varpi'M$ to the different functions of x or μ_1M, which are of interest in connection with our theory.

$\varpi'M$.	μ_1M.	Cos μ_1M.	Sin² μ_1M.	Sin² μ_1M cos μ_1M.
·0001	° ′ 0 34	·9999	·0001	·0001
·001	1 49	·9995	·0010	·0010
·01	5 43	·9951	·0099	·0099
·1	17 49	·9522	·0936	·0891
·25	27 30	·8870	·2132	·1891
·5	37 26	·7948	·3695	·2936
1	49 17	·6519	·5744	·3744
2	61 45	·4749	·7760	·3685
4	72 27	·3032	·9092	·2757
9	81 4	·1576	·9760	·1538
19	85 31	·0788	·9938	·0783
99	89 6	·0157	·9998	·0157
999	89 54	·0016	·9999	·0016
∞	90 0	0	1	0

The third column gives the ratio of the surface temperature to the central temperature for the slowest mode of cooling, the fourth the ratio of the total radiation per unit time for this rate of cooling to $4\,\frac{\varpi}{\varpi'} \times$ surface temperature, and the fifth the ratio of the same to $4\,\frac{\varpi}{\varpi'} \times$ central temperature. These relations are graphically expressed in the accompanying diagrams.

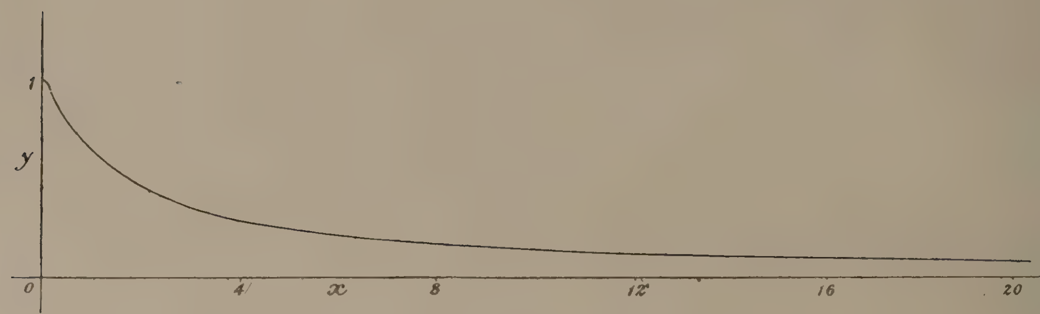

Fig. 1.

x = total mass; y = ratio of surface temperature to central temperature.

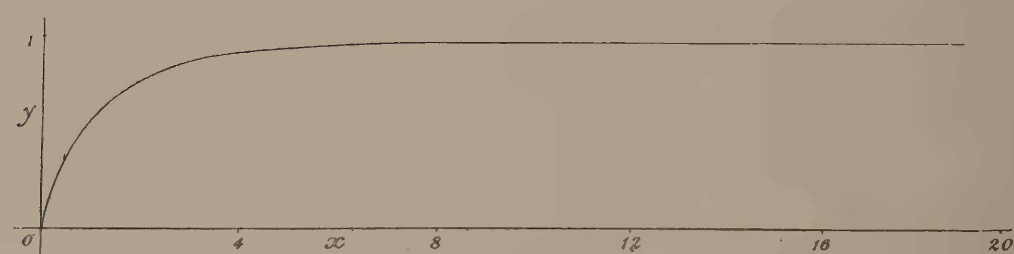

Fig. 2.

x = total mass; y = rate of radiation : surface temperature.

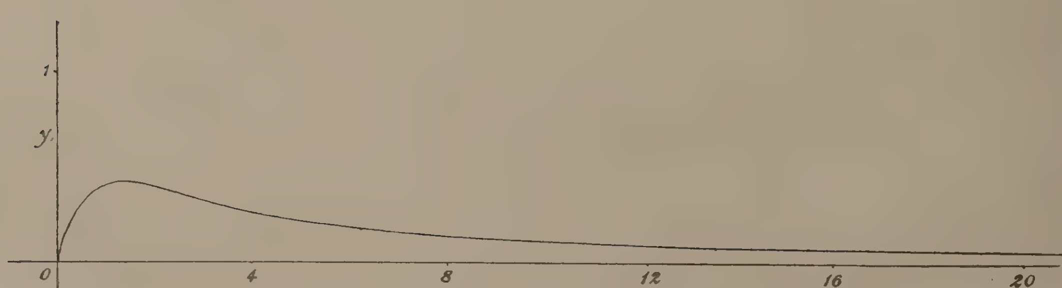

Fig. 3.

x = total mass; y = rate of radiation: central temperature.

On these relations I remark that for small mass the radiation is proportional to mass and temperature conjointly; for large mass it is equal to that of unit matter at the surface temperature with its elements isolated, and zero in comparison with the same matter at the central temperature. The relations apply only to isolated bodies, radiating freely.

Next consider the derivation of the values of μ_2, μ_3, &c. It will be observed that roots of successive orders of the equation

$$x \tan x - a = 0$$

increase by quantities which are less than π, but approach π as their limit; and that the limit for $a=0$ of the root of rth order is $(r-1)\pi$.

To find the root of $(r+1)$th order, we proceed thus:—

(1) If

$$a < \left(r + \frac{1}{4}\right)\pi,$$

write

$$x = r\pi + \tan^{-1} z;$$

then

$$z(r\pi + \tan^{-1} z) = a,$$

and the value of z derived from this equation is less than unity; hence we may expand $\tan^1 z$ in ascending powers of z, and approximate to the value of z as before. The first terms are

$$z = \frac{a}{r\pi} - \frac{a^2}{r^3\pi^3} + \frac{2a^3}{r^5\pi^5} + \left(\frac{1}{3} - \frac{5}{r^2\pi^2}\right)\frac{a^4}{r^5\pi^5} \cdot \cdot \cdot \cdot \cdot$$

(2) If

$$a = \left(r + \frac{1}{4}\right)\pi,$$

the root of $(r+1)$th order is

$$x = r\pi + \frac{\pi}{4}.$$

(3) If

$$a > \left(r + \frac{1}{4}\right)\pi,$$

put

$$x = r\pi + \frac{\pi}{2} - \tan^{-1} z;$$

then

$$(r + \tfrac{1}{2})\pi = az + \tan^{-1} z,$$

and z being less than 1, we can expand $\tan^{-1} z$ and approximate. We find

$$z = \frac{(r+\frac{1}{2})\varpi}{a+1} + \frac{1}{3}\frac{(r+\frac{1}{2})^3\varpi^3}{(a+1)^4} - \frac{3a-2}{15(a+1)^7}(r+\tfrac{1}{2})^5\varpi^5 \ldots .$$

The following table shows the values of the first five roots for five values of ϖ' M ; the entries under μM are fractions of two right angles.

ϖ'M.	μ_1M.	μ_2M.	μ_3M.	μ_4M.	μ_5M.
·00	·0000	1·0000	2·0000	3·0000	4·0000
·01	·0318	1·0010	2·0004	3·0003	4·0003
1	·2738	1·0980	2·0498	3·0335	4·0252
99	·4950	1·4850	2·4756	3·4650	4·4543
∞	·5000	1·5000	2·5000	3·5000	4·5000

In connection with this table we remark that $\cos \mu_n m$, the normal function of the nth order, has $n-1$ roots between the values $m=0$ and $m=$M. Hence, excepting the first, the separate elements $\theta_n \cos \mu_n m$ do not correspond to real distributions of temperature, since they change sign. This is a difficulty familiar to such methods of analysis, for the simplicity of such functions is on their mathematical side by design, and only accidentally on their physical side ; it will reappear in another form when we come to the problem of expressing the Sun's rotation in spherical harmonics, and we shall there see that, although the several elements of a series expressing a function change sign, the sign of their sum need not change.

It is very desirable to compare the foregoing theory with exact experience, but I am not aware of any experiments that afford a check.* For the present, the general character of the results deduced from it must be its test.

* Mr. Bottomley has made some experiments (*Phil. Trans.*, 1887, vol. clxxviii. p. 429) upon a system consisting of a tube kept at constant temperature, 16° C., enclosing a platinum wire at 408° C. and air of various degrees of tenuity. He finds an initial rapid increase of radiation with increase of mass ; but clearly conduction must play a large part in the fall of temperature from the centre to the sides.

§ 4. *Equilibrium of a Gas under the above Law of Temperature.*

We shall confine attention to spherical distributions; for such the equation of equilibrium is

$$\frac{dp}{dr} = -\gamma \frac{m\rho}{r^2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where γ is the constant of gravitation, m the mass included within radius r, ρ the density, and p the pressure.

Now we have seen that any body which continues to radiate for a time sufficiently great loses all its rates of cooling except the slowest. I shall assume this state to have arrived, and write the temperature at any point at the instant considered,

$$\theta = \theta_0 \cos \mu m,$$

where θ_0 is the central temperature, and μ the root between 0 and $\frac{\pi}{2M}$, satisfying

$$\mu \tan \mu M = \varpi'.$$

Hence

$$p = \kappa\rho\theta = \kappa\theta_0\rho \cos \mu m,$$

and the equation to be solved is

$$\frac{d}{dr}(\rho \cos \mu m) = -\frac{\gamma}{\kappa\theta_0} \frac{m\rho}{r^2} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

Change the unit of mass to $\frac{1}{\mu}$ times its former value, and the unit of length to a times its former value, a being a disposable constant. Then

$$\frac{d}{dr}(\rho \cos m) = -\alpha \frac{m\rho}{r^2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2a)$$

where

$$\alpha = \gamma / \mu a \kappa \theta_0.$$

It is easily seen that there are series proceeding by ascending powers of r which will express m and ρ.

Assume

$$m=a_0r^3[1+a_2r^2+a_4r^4+\ .\ .\ .\ .\ ]$$

and, therefore, since

$$m=\int_0^r 4\pi\rho r^2dr,$$

$$\rho=\frac{a_0}{4\pi}\Big[3+5a_2r^2+7a_4r^4+\ .\ .\ .\ .\ \Big],$$

forms which are justified by the sequel. Then

$$\cos m=1-\frac{1}{2}a_0^2r^6-a_0^2a_2r^8-a_0^2\left(a_4+\frac{1}{2}a_2^2\right)r^{10}-a_0^2\left(a_6+a_4a_2-\frac{1}{24}a_0^2\right)r^{12}\ .\ .\ .\ .$$

$$4\pi\rho\cos m=3a_0+5a_0a_2r^2+7a_0a_4r^4+(9a_0a_6-\frac{3}{2}a_0^3)r^6+11a_0\left(a_8-\frac{1}{2}a_0^2a_2\right)r_8$$

$$+13a_0\left(a_{10}-\frac{1}{2}a_0^2a_4-\frac{1}{2}a_0^2a_2^2\right)r^{10}+15a_0\left(a_{12}-\frac{1}{2}a_0^2a_6-a_0^2a_2a_4-\frac{1}{6}a_0^2a_2^3+\frac{1}{120}a_0^4\right)r^{12}\ .\ .\ .\ .$$

and

$$4\pi\rho m=a_0^2r^3\Big[3+8a_2r^2+10\left(a_4+\frac{1}{2}a_2^2\right)r^4+12(a_6+a_4a_2)r^6+14\left(a_8+a_6a_2+\frac{1}{2}a_4^2\right)r^8$$

$$+16(a_{10}+a_8a_2+a_6a_4)r_{10}\ .\ .\ .\ .\Big].$$

Substitute in the equation $(2a)$ and we find a_0 is arbitrary, and

$$2\ .\ 5a_0a_2=-\alpha\ .\ 3a_0^2$$

$$4\ .\ 7a_0a_4=-\alpha\ .\ 8a_0^2a_2$$

$$6\ .\ 9a_0\left(a_6-\frac{1}{6}a_0^2\right)=-\alpha\ .\ 10a_0^2\left(a_4+\frac{1}{2}a_2^2\right)$$

$$8\ .\ 11a_0\left(a_8-\frac{1}{2}a_0^2a_2\right)=-\alpha\ .\ 12a_0^2(a_6+a_4a_2)$$

$$10\ .\ 13a_0\left(a_{10}-\frac{1}{2}a_0^2a_4-\frac{1}{2}a_0^2a_2^2\right)=-\alpha\ .\ 14a_0^2\left(a_8+a_6a_2+\frac{1}{2}a_4^2\right)$$

$$12\ .\ 15a_0\left(a_{12}-\frac{1}{2}a_0^2a_6-a_0^2a_2a_4-\frac{1}{6}a_0^2a_2^3+\frac{1}{120}a_0^4\right)=-\alpha\ .\ 16a_0^2(a_{10}+a_8a_2+a_6a_4).$$

$$-\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .\ .$$

Hence

$$m=a_0r^3\Big[1-\frac{3}{10}a_0\alpha r^2+\frac{3}{35}a_0^2\alpha^2r^4+\left(\frac{1}{6}a_0^2-\frac{61}{2520}a_0^3\alpha^3\right)r^6+\left(-\frac{19}{110}a_0^3\alpha+\frac{631}{92400}a_0^4\alpha^4\right)r^8$$

$$+\left(\frac{22391}{200200}a_0^4\alpha^2-\frac{383}{200200}a_0^5\alpha^5\right)r^{10}+\left(\frac{3}{40}a_0^4-\frac{38227}{643500}a_0^5\alpha^3+\frac{1211923}{945945000}a_0^6\alpha^6\right)r^{12}\ .\ .\ .\ .\Big].$$

The mode in which a enters these coefficients is easily seen. Every third coefficient begins with a term independent of it, and the next two begin respectively with terms in a, a^2, and the series that form the coefficients then ascend by powers of a^3, the highest power having one-half the exponent of r.

Now in applying this formula to such a case as the Sun, it appears that all the other quantities can be made finite, while a is exceedingly small. For the greatest value of m, which is $\mu \times$ the number of grammes, is somewhat less than $\frac{\pi}{2}$, though hardly appreciably so; also taking a equal to the number of centimetres in the visible disc, viz. $6{\cdot}97 \times 10^{10}$, the range of r is from 0 to 1. But

$$a=\frac{\gamma}{\mu a\kappa\theta_0}=\frac{\gamma}{\varpi' a\kappa\theta_1},$$

where θ_1 is the surface temperature; for

$$\mu \sin \mathrm{M}=\varpi' \cos \mathrm{M}=\varpi'\theta_1/\theta_0,$$

and

$$\mathrm{M}=\frac{\pi}{2}.$$

Hence taking the above value for a,

$$\frac{\gamma}{a}=9{\cdot}3 \times 10^{-19},$$

and $\kappa\theta_1=p/\rho$ at the Sun's surface, and this can hardly be small even for vapourised dense metals. ϖ' measures the proportion of any incident heat which is absorbed by a gramme of the gas in question distributed uniformly over a thin spherical layer. This is no doubt small, but it seems improbable that it can be so small as not to leave a negligible compared with finite quantities.

Let us then ignore a; returning to the series

$$m=a_0r^3+\frac{1}{6}(a_0r^3)^3+\frac{3}{40}(a_0r^3)^5+\ldots;$$

these are the first terms of

$$\sin^{-1}(a_0r^3),$$

as they should be; for reverting to equation (2*a*), and ignoring the right-hand member

$$\cos m dm / 4\pi r^2 dr = \text{constant},$$

or

$$\sin m = a_0 r^3.$$

Hence

$$\rho = \frac{3a_0}{4\pi} \sec m,$$

and

$$\frac{dp}{dr} = 0.$$

Hence in such a body the pressure is effectively constant, and the density increases outwards from the centre. The following table expresses the distribution of mass, density, and temperature along the radius :—

r/a.	m/M.	ρ/ρ_0.	θ/θ_0.
·0	·000	1·000	1·000
·1	·001	1·000	1·000
·2	·005	1·000	1·000
·3	·017	1·000	1·000
·4	·051	1·002	·997
·5	·079	1·008	·992
·6	·138	1·024	·977
·7	·223	1·064	·939
·8	·343	1·164	·858
·9	·520	1·461	·685
1·0	1·000	∞	0

§ 5. *Stability.*

Having thus obtained the solution of the undisturbed statical equations, the most obvious comment upon the results is that the state they indicate is probably unstable. Let us therefore discuss the question of stability.

Suppose that two portions of gas, contained in equal volumes, dv, at points where the gravitation potential and density are V, ρ, V', ρ' respectively, are enclosed in rigid adiathermanous cases, and that their positions are then interchanged. Let r be the distance between their positions. Then that part of the potential energy of the whole gas which is affected by the disturbance is

$$-\frac{\rho\rho'}{r}dvdv-\rho dvV-\rho'dvV',$$

and it becomes

$$-\frac{\rho'\rho}{r}dvdv-\rho'dvV-\rho dvV';$$

so that the change results in an increase of potential energy or in a decrease according as

$$-\rho'V-\rho V'+\rho V+\rho'V'$$

is positive or negative; that is, as

$$(\rho-\rho')(V-V')$$

is positive or negative. Hence any displacement will produce an increase of potential energy if ρ and V decrease and increase together; and including the neutral case of uniform density, such cases alone will be stable.

Thus the state of equilibrium to which radiation leads is proved to be unstable. Hence it will not endure, and we must next inquire to what state it will give place.

Throughout any region where the condition for stability is unfulfilled, currents which tend to diminish the total potential energy will continually arise until their disturbances have produced the neutral state; they will then cease. On the other hand, radiation, if that be the cause of instability, will tend to restore that state which it would maintain if undisturbed. Hence there are two causes affecting the distribution of density, which respectively cease at different known points, namely, convection at a uniform distribution, and unequal radiative cooling at the distribution given on p. 144. Now if the action of these causes were sufficiently gentle, the result of their joint operation would be a distribution, which was perhaps variable, but which lay somewhere within the margin of instability at whose limits they respectively ceased. The breadth of this margin may be taken as a rough measure of their mode of action: where it is narrow the velocities of instability will be slight, and where it is broad they will be great. So that in a region where the margin is

narrow, the general distribution of density will not differ much from uniformity; but in a region where it is great, the general distribution may depart widely from uniformity, and may even approach that given by supposing continual disturbances to effect an indifferent mingling of all parts of the region. This last extreme is THOMSON's well-known law of Convective Equilibrium of Temperature, which he suggested in 1862 * as a possible relation between temperature and density in the atmosphere, and which has since been adopted by himself and other writers as a state which may be supposed to prevail within the Sun.†

According to this law

$$\theta \propto \rho^{\gamma-1},$$

where γ is the ratio of the specific heat at constant volume to the specific heat at constant pressure, a constant approximately equal to 1·4. Therefore by the criterion of p. 127, a body of gas under this law will occupy a limited space. The distribution of density to which it leads has been ably and fully discussed already.‡ The following table is derived from one given by THOMSON, who takes $\gamma = 1·4$.

r/a.	m/M.	ρ/ρ_0.	θ/θ_0.
·000	·000	1·000	1·000
·100	·033	·851	·936
·150	·062	·777	·904
·200	·134	·643	·838
·250	·235	·508	·763
·300	·349	·385	·683
·400	·594	·188	·522
·500	·765	·092	·384
·750	·973	·007	·141
1·000	1·000	·000	·000

* *Manchester Lit. and Phil. Soc. Proc.*, vol. ii. 3rd series, 1862.

† *Natural Philosophy*, vol. i. part 2, 1883, p. 492.

‡ Lane, *American Journ. Sci.*, vol. l. 2nd series, 1870, p. 57. Ritter, *Wiedemann's Annalen*, 1880, N.F., Bd. xi. p. 332 *et passim*. Thomson, *Phil. Mag.*, March 1887, p. 287. Darwin, *Phil. Trans.*, 1889, vol. clxxx. p. 1.

A glance will show how widely this distribution differs from the one which undisturbed radiation would maintain. When one-third of the mass is measured from the centre, the densities are by the two systems respectively increased and decreased in the ratios 29 : 25 and 9 : 25; for one-half the mass these ratios are 29 : 20 and 4 : 20. Now the only agency to transform the radiative distribution into the other is the disturbance caused by the encroachment beyond uniformity shown by the values of ρ/ρ_0 on p. 144. Manifestly nothing like this transformation will be produced in the main body.

But when we come to the boundaries of the mass, the case is different: the instability of equilibrium under radiation is there extreme, and we may well suppose that some such state is produced as that of convective equilibrium.

Convective equilibrium in an atmosphere the mass of which is slight compared with the main body has been considered by RITTER and by DARWIN (*l.c.*). With a view to numerical application to the Sun which I shall presently make, I here collect certain results.

Near the surface we may write

$$V=\frac{m_0}{r},$$

where m_0 is the mass of the main body. Hence

$$\rho^{\gamma-1}=m_0\frac{\gamma-1}{c\gamma}\left(\frac{1}{r}-\frac{1}{a}\right),$$

where a is the bounding radius, and c is the constant ratio $p : \rho^{\gamma}$. LANE gives three terms of a series of which this is the first. Or writing

$$A=m_0\frac{\gamma-1}{c\gamma}\ ;\ n=1/(\gamma-1)\ ;$$

$$\rho=A^n\left(\frac{1}{r}-\frac{1}{a}\right)^n.$$

The mass between radii a_0 and a is

$$\int_{a_0}^{a}4\pi r^2 dr\rho=4\pi A^n\int_{a_0}^{a}r^2\left(\frac{1}{r}-\frac{1}{a}\right)^n dr$$

or

$$m=4\pi A^n a^{3-n}\int_t^1 x^{2-n}(1-x)^n\,dx,$$

where

$$r/a=x,\ a_0/a=t.$$

If θ_0 is the temperature at $r = a_0$,

$$\theta = \theta_0 \left(\frac{1}{r} - \frac{1}{a}\right) \cdot \left(\frac{1}{a_0} - \frac{1}{a}\right)$$

$$= \theta_0 \cdot \frac{t}{x} \frac{1-x}{1-t}.$$

If a constant s measures the thermometric capacity of the gas, the total heat contained in this atmosphere is

$$h = \int_{a_0}^{a} 4\pi r^2 dr \rho s \theta$$

$$= 4\pi \frac{st}{1-t} A^n a^{3-n} \partial_0 \int_t^1 x^{1-n}(1-x)^{n-1} dx.$$

The quantity of heat it would contain if all were at the temperature of the lowest stratum is

$$h_0 = 4\pi s A^n a^{3-n} \theta_0 \int_t^1 x^{2-n} (1-x)^n dx,$$

and

$$h : h_0 = \frac{t}{1-t} \frac{\int_t^1 x^{1-n}(1-x)^{n+1} dx}{\int_t^1 x^{2-n}(1-x)^n dx}.$$

If we take n to be 2·5, all these integrals are rationalised by substituting $x = \sin^2 \theta$. Calculating on this supposition, I have found the following values for $h : h_0$:—

$\frac{a}{a_0}$	$\frac{4}{3}$	2	5	10	100	10,000	∞
$\frac{h}{h_0}$	·743	·669	·527	·339	·178	·013	0

Or if an atmosphere in convective equilibrium surround a central core of constant temperature, the less the total heat contained in the atmosphere, the greater is its altitude; in other words, it extends outwards as it cools. A like theorem is given by RITTER.*

* *Wiedemann's Annalen*, 1880, N.F., Bd. xi. p. 981.

§ 6. *Application to the Sun.*

Assuming that the foregoing theory describes the mechanical state of the Sun, let us shortly review its results.

We have seen that, owing to radiation, the Sun's entire body is in an unsettled state, agitated in some degree by convection currents. The degree of this instability proceeds from zero to infinity ; while the convection currents in the inner half of the body can hardly be strong enough to produce even a uniform distribution of density. As we go outwards the degree becomes higher and higher, accompanied by more and more violent convection currents, until at length with infinite violence we find that tremendous state of turmoil, as STOKES has called it, that visibly possesses the Sun's extremes. There seems good reason to believe that there is not habitually any violent disturbance at the depth at which the umbra of the Sun spots lie. If this be so, gentle convection currents must prevail over an extent beyond that which our theory foresees, and we may assert that the density of the Sun is practically uniform throughout ; but in any case the central density cannot be many times greater than the mean.

Moreover, when we descend below what may be called the atmosphere, say below the level of the Sun spot umbra, we should also find both temperature and pressure thence inwards to the centre practically uniform.

Our theory also supplies a view of the solar radiations.

Taking the solar constant at 25 calories,* we find the total quantity of heat radiated from the Sun per second to be $1 \cdot 14 \times 10^{23}$ calories. If we simply equate this to the expression of p. 135, putting

$$\mu_1 M = \frac{\pi}{2},$$

we have

$$4 \frac{\varpi}{\varpi'} \theta_1,$$

where θ_1 is the surface temperature, and we obtain a value of θ_1 which is inconceivably great. The significance of this becomes plain by our theory.

* Young, *The Sun*, p. 279.

For the formula of p. 135 postulates no disturbance, and, subject to that, we see by p. 144 that gravitation of the parts would build up an infinitely dense crust around the body through which all radiations from the central parts must pass. So that, be the central temperature as great as it may, the radiations of such a body would be virtually zero.

Let us therefore follow the manner in which the disturbances of instability increase the total radiations. We have seen on p. 139 that while an isolated large body radiates only in proportion to its outward temperature, its mass having very little influence, an isolated small body radiates in proportion to its temperature and its mass conjointly.

Now the effect of convection currents in carrying matter to the confines of the atmosphere is precisely to isolate successively small bodies of gas charged with heat, which thus advance, discharge their artillery, and retire. Hence the radiations from an atmosphere subject to violent convection currents will be the same as the sum of its radiations were all its parts isolated, that is, in proportion to its mass.

Since we have no estimate of the value of the constant ϖ, we cannot thence derive a value for the Sun's surface temperature; but by some such argument as the following we may, I think, show that it need not be unreasonably high.

Assume that convective equilibrium prevails in the Sun's atmosphere, and for definiteness suppose this atmosphere consists of hydrogen and extends to a depth at which the pressure is a megadyne per square centimetre, and that the temperature is there 10,000° C., or, say, 40 times that of freezing water; also take $\gamma = 1{\cdot}4$. Then we have,* if

$$p=10^6,\ \theta=1,\ \rho=8{\cdot}837\times10^{-5};$$

so that

$$\theta=40,\ \rho=2{\cdot}209\times10^{-6};$$

and putting

$$p=c\rho^\gamma,$$

$$c=8{\cdot}281\times10^{13}.$$

Writing

$$\rho^{\gamma-1}=\frac{m_0}{a}\frac{\gamma-1}{c\gamma}\left(\frac{a}{r}-1\right),$$

---

* Everett, *C.G.S. System of Units*, 1891, p. 41.

and taking *

$$a = 6{\cdot}97 \times 10^{10} \text{ cm};$$
$$m_0 = 3{\cdot}3 \times 10^5 \times \text{Earth's astronomical mass}$$
$$= 3{\cdot}3 \times 10^5 \times 3{\cdot}98 \times 10^{20}\,\dagger,$$

we get

$$\frac{m_0}{a} = 1{\cdot}88 \times 10^{15},$$

and

$$\rho = 1{\cdot}077 \times 10^2 \left(\frac{a}{r} - 1\right)^{\frac{5}{2}}.$$

Hence the value of a/r which makes

$$\rho = 2{\cdot}209 \times 10^{-6}$$

is

$$a/r = 1{\cdot}000841,$$

and the thickness of the layer under discussion is

$$8{\cdot}41 \times 10^{-4} \times \text{Sun's radius}$$
$$= 365 \text{ miles.}$$

Also the Sun's density is $1{\cdot}406$.‡

Now employing the formulæ of p. 147, with these data, we find for this layer

$$\text{mass} = 3{\cdot}777 \times 10^{-10} \times \text{Sun's mass};$$
$$\text{volume} = 2{\cdot}52 \times 10^{-3} \times \text{Sun's volume};$$
$$\text{heat} = 7{\cdot}029 \times 10^{25} \times \text{specific heat of hydrogen.}$$

This gives the total radiation from the layer

$$\varpi \times 7{\cdot}029 \times 10^{25},$$

which would require

$$\varpi = 1{\cdot}55 \times 10^{-3}$$

in order to procure an agreement with observations. Though we do not know the value of ϖ, it seems safe to affirm that it must be considerably greater than this—that is, that an isolated small body of hydrogen would lose heat considerably faster than at the rate of $\frac{1}{600}$ per second. Therefore we may also safely affirm that our theory would explain the observed radiations with a temperature not greater than 10,000° C. at a depth that may be called the base of the atmosphere. It will then follow that the central temperature

* Young, *The Sun*, 1892, p. 278. † Everett, p. 74. ‡ Young, *l.c.*, p. 278.

is not many times greater than this, a moderate estimate which will avoid some theoretical difficulties as to the source whence the Sun has drawn his stores of energy.

The conclusion that the Sun's atmosphere is his chief radiator was to me a novel one; but I have since found that it has already been adopted by others, for the reason that it removes that stumbling-block, the darkness of the Sun spots. We now see how this should be. We must suppose the spots to lie at a level below the violent currents of the atmosphere, so that they share in the slow radiation of the main body.*

The word "atmosphere" has been used somewhat loosely to refer to those parts that are subject to the violent convection currents of the outer surface; because when the time arrives in the cooling of any heavenly body at which it ceases to be wholly gaseous and becomes mainly liquid or solid, these outward disturbed parts will settle into the position of a gaseous cloak. As this cloak throws off its own heat and that acquired from the core, which cools more slowly, we have at succeeding epochs such states as are dealt with on p. 148, in which $h : h_0$ is continually decreasing.

Hence with lapse of time the atmosphere spreads outwards, and its density at the core decreases, both without limit. This is obviously a sufficient explanation, if we had no other, of the present state of the atmosphere of the Moon. Observations render it probable, or even certain,† that there is still an atmosphere of finite density upon our satellite; if so, it has not yet reached the final stage.

Unless, indeed, the total quantity of ponderable matter in the universe is infinite; for then the final density of the atmosphere of any planet would be finite, while a gas of like constitution would extend throughout space, condensing around other planets and the Sun, and thence away in extreme tenuity through interstellar space to the stars. Weakness of analysis as well as ignorance of the ultimate structure of gases compel us to treat them at present by their average effects, but it seems not beyond possibility that we shall some day definitely answer this profound question.

* Since the publication of Mr. Howlett's observations (*M. N.*, vol. lv. 1894 Dec.), it appears that we must consider Wilson's theory unproved. However, our argument asserts no more than that the darkness is due to the absence of violent disturbances, so that a spot may be regarded as a specimen of the Sun's face as it would appear if there were no convection currents.

† Neison, *The Moon*, 1876, p. 34.

Part II.

THE ROTATION OF THE SUN.

§ 1. *Lines of the Solution Proposed.*

Some experiments have been made by M. Belopolsky to illustrate the rotation of the Sun.* A hollow sphere of glass, 86·86 mm. in radius, with meridians and parallels marked upon it, was filled with water holding finely powdered stearin, or other solid matter, in suspension. This was placed in a centrifugal machine and rotated until the entire mass of water had acquired a velocity of forty revolutions per minute ; the glass sphere was then brought gradually to rest, and the motions of the particles of stearin were watched, with a view to detecting the drift of the water. It was observed that particles near the surface passed spirally from the regions of the equator to those of the poles with an angular velocity that, up to a certain point,† decreased with the colatitude. This significant result convinced the experimenter that the law of the Sun's rotation was susceptible of mechanical explanation upon similar lines. Let us consider in general terms what this explanation must be.

When the glass sphere is brought to rest, we shall have a rotating system in which, along any radius, the angular motion increases inwards. Consider this system, for the moment, apart from internal friction. We may write the equation of the surfaces of equal angular motion in the form

$$r = \mathrm{R}\,(1 - \epsilon\cos^2\theta),$$

where θ is the colatitude, ϵ is proportional to the square of the angular motion, supposed small, and R increases as ϵ diminishes. Where this family meets any sphere $r=a$, we have

$$\frac{d\epsilon}{d\theta} = \frac{2\epsilon\sin\theta\cos\theta}{\cos^2\theta + \frac{d}{d\epsilon}\left(\frac{a}{\mathrm{R}}\right)};$$

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* *Astron. Nach.*, No. 2954.

† The minimum was generally beyond lat. 45° N. or S. Before reaching the poles the particles turned back into the body of the fluid.

the right-hand member vanishes at the poles and the equator, and is positive between ; so that it has a maximum in the middle latitudes at a point that depends upon the relation of R and ϵ. Hence travelling from the poles to the equator along any sphere, *e.g.* the glass boundary, we should find the angular motion associated with a parallel increasing continually with the colatitude at a progressive rate which was greatest in the middle latitudes.

Consider now the effect of viscosity upon such a system. Relative motions, other than those possible to a rigid body, will gradually become effaced, and in the process local differences of character will disappear. Thus, even if the bounding sphere were a free surface, and therefore an exception, in inviscid liquids, to the above argument, friction would confer upon it the feature of a progressive angular motion of the same description as that found upon any concentric spherical surface within.

The observations which I take as data of the Sun's rotation are those of M. Dunér. *

Latitude.	Daily Angular Rotation.	Rate of Decrease per Degree of Lat.
° ′	°	
0 24	14·14	
		·033
15 0	13·66	
		·040
30 0	13·06	
		·071
45 0	11·99	
		·091
60 0	10·62	
		·085
74 48	9·34	

This motion is of the character we have described ; therefore we can explain it by a similar theory, namely, friction affecting a fluid body whose rotation is greatest in the inward parts. The remainder of my essay is devoted to determining, with such precision as may be possible, that state of internal motion that is implied in the explanation.

Probably it will be considered, in the present state of our knowledge, that such a constitution in the Sun is not at all unlikely ; but if we admit it

* *Astron. Nach.*, No. 2963 (1890).

for the Sun, it follows, by NEWTON'S *Regula Philosophandi II.*, that we must also accept it for Jupiter and Saturn, in whose surfaces, upon favourable occasions, similar motions have been observed.*

§ 2. *Equations of Motion.*

Let us write down the equations of motion of a viscous gas, assuming that the coefficient of viscosity is variable with the temperature, and thence a function of the coordinates.

Referring the equations to fixed rectangular axes, with the usual notation,

$$\frac{d\rho}{dt}+\frac{d\,(\rho u)}{dx}+\frac{d\,(\rho v)}{dy}+\frac{d\,(\rho w)}{dz}=0,$$

$$\rho\frac{\partial u}{\partial t}=\rho\mathrm{X}+\frac{d\mathrm{P}}{dx}+\frac{d\mathrm{U}}{dy}+\frac{d\mathrm{T}}{dz},$$

$$\rho\frac{\partial v}{\partial t}=\rho\mathrm{Y}+\frac{d\mathrm{U}}{dx}+\frac{d\mathrm{Q}}{dy}+\frac{d\mathrm{S}}{dz},$$

$$\rho\frac{\partial w}{\partial t}=\rho\mathrm{Z}+\frac{d\mathrm{T}}{dx}+\frac{d\mathrm{S}}{dy}+\frac{d\mathrm{R}}{dz},$$

where

$$\frac{\partial}{\partial t}=\frac{d}{dt}+u\frac{d}{dx}+v\frac{d}{dy}+w\frac{d}{dz},$$

$$\mathrm{P}=-p-\frac{2}{3}\mu\delta+2\mu\frac{du}{dx},$$

$$\mathrm{S}=\mu\left(\frac{dw}{dy}+\frac{dv}{dz}\right),$$

$$\delta=\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}.$$

Transform these expressions so that the independent variables are ϖ, θ, z, where

$$x=\varpi\cos\theta,\quad y=\varpi\sin\theta,\quad z=z,$$

and the dependent variables the resolved parts of u, v, w in the directions of ϖ, perpendicular to ϖ and z, and of z respectively, — quantities which by

* *Jupiter:* Cf. Clerke, *History of Astron.*, p. 336. *Saturn:* Williams, *M.N.*, 1894 March.

changing the meaning of u, v, w we shall still denote by those letters. We find

$$\frac{\partial u}{\partial t}-\frac{v^2}{\varpi}=\frac{dQ}{d\varpi}+\frac{1}{3}\frac{\mu}{\rho}\frac{d\delta}{d\varpi}+\frac{\mu}{\rho}\left(\nabla^2 u-\frac{u}{\varpi^2}-\frac{2}{\varpi^2}\frac{dv}{d\theta}\right)+\frac{1}{\rho}\frac{d\mu}{d\varpi}\left(-\frac{2}{3}\delta+2\frac{du}{d\varpi}\right)+\frac{1}{\rho}\frac{d\mu}{\varpi d\theta}\left(\frac{dv}{d\varpi}-\frac{v}{\varpi}+\frac{1}{\varpi}\frac{du}{d\theta}\right)$$
$$+\frac{1}{\rho}\frac{d\mu}{dz}\left(\frac{du}{dz}+\frac{dw}{d\varpi}\right),$$

$$\frac{\partial v}{\partial t}+\frac{uv}{\varpi}=\frac{dQ}{\varpi d\vartheta}+\frac{1}{3}\frac{\mu}{\rho}\frac{d\delta}{\varpi d\vartheta}+\frac{\mu}{\rho}\left(\nabla^2 v-\frac{v}{\varpi^2}+\frac{2}{\varpi^2}\frac{du}{d\theta}\right)+\frac{1}{\rho}\frac{d\mu}{d\varpi}\left(\frac{dv}{d\varpi}-\frac{v}{\varpi}+\frac{du}{\varpi d\vartheta}\right)$$
$$+\frac{1}{\rho}\frac{d\mu}{\varpi d\theta}\left(-\frac{2}{3}\delta+2\frac{dv}{\varpi d\vartheta}+2\frac{u}{\varpi}\right)+\frac{1}{\rho}\frac{d\mu}{dz}\left(\frac{dw}{\varpi d\vartheta}+\frac{dv}{d}\right)$$

$$\frac{\partial w}{\partial t}=\frac{dQ}{dz}+\frac{1}{3}\frac{\mu}{\rho}\frac{d\delta}{dz}+\frac{\mu}{\rho}\nabla^2 w+\frac{1}{\rho}\frac{d\mu}{d\varpi}\left(\frac{du}{dz}+\frac{dw}{d\varpi}\right)+\frac{1}{\rho}\frac{d\mu}{\varpi d\theta}\left(\frac{dw}{\varpi d\vartheta}+\frac{dv}{dz}\right)+\frac{1}{\rho}\frac{d\mu}{dz}\left(-\frac{2}{3}\delta+2\frac{dw}{dz}\right),$$

where

$$Q=\int\left(Xdx+Ydy+Zdz-\frac{dp}{\rho}\right),$$

$$\varpi\frac{d\rho}{dt}+\frac{d}{d\varpi}(\rho\varpi u)+\frac{d}{d\vartheta}(\rho v)+\varpi\frac{d}{dz}(\rho w)=0.$$

$$\delta=\frac{du}{d\varpi}+\frac{dv}{\varpi d\theta}+\frac{dw}{dz}+\frac{u}{\varpi},$$

$$\frac{\partial}{\partial t}=\frac{d}{dt}+u\frac{d}{d\varpi}+v\frac{d}{\varpi d\theta}+w\frac{d}{dz}.$$

§ 3. *Simplifications of the Problem.*

The rotation of the Sun may be considered to be approximately steady, and independent of the azimuth. Therefore, in seeking to express it, we must look for solutions of the equations just written which give motions of this character in a self-coherent spherical body. Take the origin at the centre of the sphere, and let z be the axis of rotation.

Integration will introduce an arbitrary parameter which may be taken to be the angular velocity of some definite particle about the axis of z. If u, v, w be developed in ascending powers of this arbitrary, and the expressions substituted in our equations, the coefficient of every power of the arbitrary in the resulting expressions must separately vanish. Hence we may employ a method of successive approximation, ignoring at each stage all terms which would introduce a higher power of the arbitrary than those we wish to consider.

Now it is manifest by inspection that v alone involves the first power of this arbitrary (and after that odd powers exclusively), while u and w involve the second and higher even powers. Hence we begin with the second of the dynamical equations, omitting all terms that would introduce cubes of the angular velocity, or which vanish for other reasons; and as we shall not find it necessary to refine upon this approximation, I shall associate the symbol v with the terms so found.

The equation becomes

$$0=\frac{\mu}{\rho}\left(\nabla^2 v-\frac{v}{\varpi^2}\right)+\left(\frac{dv}{d\varpi}-\frac{v}{\varpi}\right)\frac{1}{\rho}\frac{d\mu}{d\varpi}+\frac{dv}{dz}\frac{1}{\rho}\frac{d\mu}{dz},$$

or taking μ a function of the radius vector alone, so that

$$\frac{d\mu}{d\varpi}=\frac{\varpi}{r}\frac{d\mu}{dr}, \quad \frac{d\mu}{dz}=\frac{z}{r}\frac{d\mu}{dr},$$

$$0=\frac{d^2v}{d\varpi^2}+\frac{1}{\varpi}\frac{dv}{d\varpi}+\frac{d^2v}{dz^2}-\frac{v}{w^2}+\frac{1}{\mu}\frac{d\mu}{dr}\left(\frac{dv}{dr}-\frac{v}{r}\right),$$

or, again, in terms of r, and $x \equiv \sin$ (latitude),

$$0=\frac{d^2v}{dr^2}+\frac{2}{r}\frac{dv}{dr}+\frac{1-x^2}{r^2}\frac{d^2v}{dx^2}-\frac{2x}{r^2}\frac{dv}{dx}-\frac{v}{r^2(1-x^2)}+\frac{1}{\mu}\frac{d\mu}{dr}\left(\frac{dv}{dr}-\frac{v}{r}\right).$$

Now if we write

$$v=\Sigma z_n(r)y_n(x),$$

where

$$0=(1-x^2)\frac{d^2y_n}{dx^2}-2x\frac{dy_n}{dx}-\frac{y_n}{1-x^2}+n(n-1)y_n,$$

then z_n must be a solution of

$$0=\frac{d^2z_n}{dr^2}+\frac{2}{r}\frac{dz_n}{dr}-\frac{n(n-1)}{r^2}z_n+\frac{1}{\mu}\frac{d\mu}{dr}\left(\frac{dz_n}{dr}-\frac{z_n}{r}\right).$$

But the equation for y_n is well known: its solutions are

$$(1-x^2)^{\frac{1}{2}}\left(A_n\frac{dP_{n-1}}{dx}+B_n\frac{dQ_{n-1}}{dx}\right),$$

where P_{n-1}, Q_{n-1} are zonal harmonics of order n, or; as I shall find it convenient to write it,

$$(1-x^2)^{-\frac{1}{2}}\left(A_nI_n(x)+B_nH_n(x)\right),$$

where I_n, H_n are functions which I have discussed in another paper,* whence I shall quote their properties as occasion may require.

By a well-established experimental law, $\mu \propto$ absolute temperature; therefore, to solve the equation for z_n, we require to know the temperature as a function of the radius—a problem which led me to the theory developed in Part I. of this essay. We have there seen that to call the temperature uniform throughout the main body is not far from the truth; not to confuse a difficult question with inessential complexities, let us put

$$\frac{1}{\mu}\frac{d\mu}{dr}=0,$$

so that

$$z=C_n r^{n-1}+D_n r^{-n}.$$

§ 4. *Mode of Solution.*

When the problem arises of expressing a function in solid harmonics, it is generally assumed that the value of the function is exactly known at all points of two surfaces. In the present case our knowledge falls short in three respects: first, it is inexact; secondly, it is limited to discrete points; and lastly, we can only observe a single surface. Let us consider these features in turn, and, to take advantage of a familiar terminology, let us speak as if it were a problem in potential.

If a potential function is known at all points of a surface with a maximum error ϵ, the value which we thence deduce for its value in free space is not thereby subject to an error greater than ϵ.† This settles the case of inexact data, *e.g.*, the use of an empirical formula which is approximate; and it shows, moreover, that if we have two different expressions derived from the same data (as we may, if we do not confine ourselves to integral harmonics), the values of these cannot differ from one another throughout the entire region governed by the data, however wide the difference of their forms may be.

The data invariably enter the solution through definite integrals; as in

* *Phil. Trans.*, vol. clxxxii. (1891).

† *Cf.* Stokes, *Collected Papers*, vol. ii. p. 110, prop. v. cor. 2.

the development of a function $f(x)$ in Legendre's functions, all we require is the value of the series of integrals

$$\int_{-1}^{+1} f(x) P_n(x) dx$$

for all integral values of n. To find this integral when $f(x)$ is not known generally, but only for a number of discrete values of x, is the problem of mechanical quadratures, about which, therefore, no more need be said than that it will be generally advisable to derive by interpolation the value of $f(x)$ at certain points chosen in accordance with the rules of mechanical quadratures. If we use m values to effect the integration, it is known that, in defect of further details, these should be the values of x given by $P_m(x)=0$. We may take m different for each term; provided n is not too small, let $m=n$, and the integral vanishes. In other words, we may always omit the higher terms in a spherical harmonic development with a known small error.

The third feature of the data is that they are derived from one surface only; and this, strictly, leaves the problem indeterminate; nevertheless we may make a considerable step towards its solution.

First find an expression of the simplest form which can be made to agree with the surface observations within their own probable errors, and which also embodies the condition that the angular motion increases inwards along all radii. This will give one state of motion which is consistent with the facts, and all others are found by supplementing it with an infinite series of terms which vanish at the surface of observation, but which are otherwise indeterminate.

It is not an easy matter to find an expression which increases inwards along all radii, because the surface functions have a number of internal roots between the extreme values of their argument, and separate terms will therefore give an increase in some parts and a decrease in others. There are only two harmonics of integral order with no internal roots (as $P_0(x)=1, P_1(x)=x$); but if we take the fractional harmonics between these two we have an infinite variety of eligible expressions which do not change sign. These are what I employ; the method of employment will be explained in the following section, where an expression for the observations will be found in terms of them. But as it is unusual to employ fractional harmonics where

the analysis presents integral ones with equal directness, I shall here add some remarks upon their relations to one another.

The theorem

$$f(x)=\Sigma\frac{2n+1}{2}P_n(x)\int_{-1}^{+1}f(x)P_n(x)dx,$$

where the summation includes all positive integers, for all values of x between $+1$ and -1, is still true when $f(x)$ is another harmonic. Let us find the developments of $P_m(x)$, $Q_m(x)$, where m may be fractional.

We have

$$(1-x^2)\frac{d^2P_n}{dx^2}-2x\frac{dP_n}{dx}+n(n+1)P_n=0,$$

$$(1-x^2)\frac{d^2P_m}{dx^2}-2x\frac{dP_m}{dx}+m(m+1)P_m=0,$$

whence

$$(m-n)(m+n+1)\int_0^1 P_mP_n dx=\Big[(1-x^2)(P_mP_n'-P_nP_m')\Big]_0^1$$

Similarly

$$(m-n)(m+n+1)\int_0^1 Q_mP_n dx=\Big[(1-x^2)(Q_mP'_n-P_nQ'_m)\Big]_0^1$$

But it is known

$$P_m(x)=\frac{\xi^{-m}}{\pi}\int_{\xi^2}^1\frac{u^m du}{(1-u)^{\frac{1}{2}}(u-\xi^2)^{\frac{1}{2}}},\ Q_m(x)=\xi^{m+1}\int_0^1\frac{u^m du}{(1-u)^{\frac{1}{2}}(1-u\xi^2)^{\frac{1}{2}}},$$

where

$$2x=\xi+\frac{1}{\xi}.$$

Therefore

$$P_m(-x)=e^{im\pi}P_m(x),\qquad Q_m(-x)=e^{-i(m+1)\pi}Q_m(x);$$

and

$$\int_{-1}^{+1}P_mP_n dx=\frac{1+e^{i(m+n)\pi}}{(m-n)(m+n+1)}\Big[(1-x^2)(P_mP'_n-P_nP'_m)\Big]_{+0}^{+1}$$

$$\int_{-1}^{+1}Q_mP_n dx=\frac{1-e^{i(n-m)\pi}}{(m-n)(m+n+1)}\Big[(1-x^2)(Q_mP'_n-P_nQ'_m)\Big]_{+0}^{+1}$$

Now we have

$$P_m(1)=\underset{\xi=1}{\mathrm{Lt}}\ \frac{1}{\pi}\int_{\xi^2}^1\frac{u^m du}{(1-u)^{\frac{1}{2}}(u-\xi^2)^{\frac{1}{2}}};$$

put

$$\xi^2=1-\epsilon,\qquad u=1-t\epsilon;$$

then

$$P_m(1) = \underset{\epsilon=0}{\mathrm{Lt}}\, \frac{1}{\pi}\int_0^1 \frac{dt}{t^{\frac{1}{2}}(1-t)^{\frac{1}{2}}} = 1.$$

$$P_m(0) = \frac{1}{\pi} e^{-im\frac{\pi}{2}} \int_{-1}^{+1} \frac{u^m du}{(1-u^2)^{\frac{1}{2}}}$$

$$= \frac{1}{\pi}\left[e^{-im\frac{\pi}{2}} \int_0^1 \frac{u^m du}{(1-u^2)^{\frac{1}{2}}} + e^{im\frac{\pi}{2}} \int_0^1 \frac{u^m du}{(1-u^2)^{\frac{1}{2}}}\right]$$

$$= \frac{\Pi\left(\frac{m-1}{2}\right)}{\Pi\left(-\frac{1}{2}\right)\Pi\left(\frac{m}{2}\right)} \cos \frac{m\pi}{2}.$$

Also

$$(1-x^2)P'_m(x) = (m+1)[xP_m(x) - P_{m+1}(x)];$$

therefore

$$P'_m(0) = \frac{\Pi\left(\frac{m}{2}\right)}{\Pi\left(\frac{1}{2}\right)\Pi\left(\frac{m-1}{2}\right)} \sin \frac{m\pi}{2},$$

$$\underset{x=1}{\mathrm{Lt}}(1-x^2)P'_m(x) = 0.$$

Hence we have

$$\int_{-1}^{+1} P_m P_n dx = \frac{2\cos(m+n)\frac{\pi}{2} e^{i(m+n)\frac{\pi}{2}}}{(m-n)(m+n+1)} \cdot \frac{2}{\pi}\left[\frac{\Pi\left(\frac{m}{2}\right)\Pi\left(\frac{n-1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)\Pi\left(\frac{n}{2}\right)} \sin \frac{m\pi}{2} \cos \frac{n\pi}{2} - \frac{\Pi\left(\frac{n}{2}\right)\Pi\left(\frac{m-1}{2}\right)}{\Pi\left(\frac{n-1}{2}\right)\Pi\left(\frac{m}{2}\right)} \sin \frac{n\pi}{2} \cos \frac{m\pi}{2}\right]$$

We observe that when n is an integer, one of the terms vanishes, the first when n is odd, and the second when n is even; when m is also an integer, the other term vanishes when $m+n$ is even, and the factor outside the brackets when $m+n$ is odd.

Thus writing

$$C_{2r} = (-1)^r \frac{2}{\pi} \frac{4r+1}{2} \frac{1}{(m-2r)(m+2r+1)} \frac{\Pi\left(\frac{m}{2}\right)\Pi\left(r-\frac{1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)\Pi(r)},$$

$$C_{2r-1} = (-1)^r \frac{2}{\pi} \frac{4r-1}{2} \frac{1}{(m-2r+1)(m+2r)} \frac{\Pi\left(\frac{m-1}{2}\right)\Pi\left(r-\frac{1}{2}\right)}{\Pi\left(\frac{m}{2}\right)\Pi(r-1)},$$

we have the development

$$P_m(x)=\Sigma \sin m\pi\left[e^{im\frac{\pi}{2}}C_{2r}P_{2r}(x)+e^{i(m-1)\frac{\pi}{2}}C_{2r-1}P_{2r-1}(x)\right].$$

Change the sign of x throughout, and we get

$$P_m(-x)=\Sigma e^{im\pi}\sin m\pi\left[e^{-im\frac{\pi}{2}}C_{2r}P_{2r}(x)+e^{-i(m-1)\frac{\pi}{2}}C_{2r-1}P_{2r-1}(x)\right];$$

but

$$P_m(-x)=e^{im\pi}P_m(x);$$

hence the imaginary part of $P_m(x)$ vanishes when x is positive, and we may write

$$1>x>0;$$

$$\begin{aligned}P_m(x)=\frac{\sin m\pi}{\pi}\Bigg\{&\cos\frac{m\pi}{2}\,\frac{\Pi\left(\frac{m}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)}\left[\Sigma(-1)^r\frac{4r+1}{(m-2r)(m+2r+1)}\,\frac{\Pi\left(r-\frac{1}{2}\right)}{\Pi(r)}P_{2r}(x)\right]\\&+\sin\frac{m\pi}{2}\,\frac{\Pi\left(\frac{m-1}{2}\right)}{\Pi\left(\frac{m}{2}\right)}\left[\Sigma(-1)^r\frac{4r-1}{(m-2r+1)(m+2r)}\,\frac{\Pi\left(r-\frac{1}{2}\right)}{\Pi(r-1)}P_{2r-1}(x)\right]\Bigg\};\end{aligned}$$

and this expression passes continuously into $P_m(-x)$ by help of the identity

$$1>x>0;$$

$$\begin{aligned}0=\frac{\sin m\pi}{\pi}\Bigg\{&\sin\frac{m\pi}{2}\,\frac{\Pi\left(\frac{m}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)}\left[\Sigma(-1)^r\frac{4r+1}{(m-2r)(m+2r+1)}\,\frac{\Pi\left(r-\frac{1}{2}\right)}{\Pi(r)}P_{2r}(x)\right]\\&-\cos\frac{m\pi}{2}\,\frac{\Pi\left(\frac{m-1}{2}\right)}{\Pi\left(\frac{m}{2}\right)}\left[\Sigma(-1)^r\frac{4r-1}{(m-2r+1)(m+2r)}\,\frac{\Pi\left(r-\frac{1}{2}\right)}{\Pi(r-1)}P_{2r-1}(x)\right]\Bigg\}.\end{aligned}$$

It is easy to verify that for integral m, the right-hand member of the former expression reduces to $P_m(x)$, while that of the latter vanishes.

It is to be observed that an expression which represents $P_m(x)$ for both positive and negative values of the argument is complex, but if the expression is to apply only for $1>x>0$, the form that represents it is to a large extent arbitrary; for then for $0>x>-1$, the value of $f(x)$ of p. 160 is no longer given.

In each case, along with the expression which is equal to $P_m(x)$ for x positive there will appear an algebraical identity of like character to the above.

Next we find the development of $Q_m(x)$.

We find

$$Q_m(0)=e^{i(m+1)\frac{\pi}{2}}\frac{\Pi\left(\frac{m-1}{2}\right)\Pi\left(\frac{1}{2}\right)}{\Pi\left(\frac{m}{2}\right)};$$

$$\underset{x=1}{\mathrm{Lt}}(1-x^2)Q_m(1)=0\,;$$

$$(1-x^2)Q'_m(x)=(m+1)[xQ_m(x)-Q_{m+1}(x)],$$

$$Q'_m(0)=e^{im\frac{\pi}{2}}\frac{\Pi\left(\frac{m}{2}\right)\Pi\left(-\frac{1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)}$$

$$\underset{x=1}{\mathrm{Lt}}(1-x^2)Q'_m(x)=(m+1)\underset{x=1}{\mathrm{Lt}}\int_0^{\frac{1}{2}\log\frac{x+1}{x-1}}dv\cosh v\sqrt{x^2-1}(x-\cosh v\sqrt{x^2-1})^m$$

$$=(m+1)\underset{x=1}{\mathrm{Lt}}\int_{\sqrt{x^2-1}}^{x}dt\frac{t}{\sqrt{t^2-x^2+1}}(1-t)^m \qquad [t=\cosh v\sqrt{x^2-1}$$

$$=(m+1)\underset{x=1}{\mathrm{Lt}}\int_0^1 dt(1-t)^m=1.$$

Thus we find

$$\int_{-1}^{+1}Q_m(x)P_n(x)dx=\frac{1-e^{i(n-m)\pi}}{(m-n)(m+n+1)}\left[-1+\frac{\Pi\left(\frac{n}{2}\right)\Pi\left(\frac{m-1}{2}\right)}{\Pi\left(\frac{n-1}{2}\right)\Pi\left(\frac{m}{2}\right)}\sin\frac{m\pi}{2}\sin\frac{n\pi}{2}\right.$$

$$+\frac{\Pi\left(\frac{m}{2}\right)\Pi\left(\frac{n-1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)\Pi\left(\frac{n}{2}\right)}\cos\frac{m\pi}{2}\cos\frac{n\pi}{2}-i\left\{\frac{\Pi\left(\frac{n}{2}\right)\Pi\left(\frac{m-1}{2}\right)}{\Pi\left(\frac{n-1}{2}\right)\Pi\left(\frac{m}{2}\right)}\sin\frac{n\pi}{2}\cos\frac{m\pi}{2}\right.$$

$$\left.\left.-\frac{\Pi\left(\frac{m}{2}\right)\Pi\left(\frac{n-1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)\Pi\left(\frac{n}{2}\right)}\cos\frac{n\pi}{2}\sin\frac{m\pi}{2}\right\}\right].$$

And this is the coefficient of $P_n(x)$, in the development of $Q_m(x)$ divided by $\frac{2n+1}{2}$. Changing the sign of x is equivalent to multiplying by $e^{-in\pi}$.

Hence the corresponding term in $Q_n(-x)$ is the same expression within [] multiplied by

$$\frac{e^{-in\pi}-e^{-im\pi}}{(m-n)(m+n+1)}.$$

But

$$Q_m(-x)=-e^{-im\pi}Q_m(x).$$

Hence we may also write the multiplier for $Q_m(x)$, where x is positive,

$$\frac{1-e^{i(m-n)\pi}}{(m-n)(m+n+1)}.$$

Adding the two forms, we find

$$1>x>0,$$

$$Q_m(x)=\Sigma\frac{4r+1}{(m-2r)(m+2r+1)}\sin^2\frac{m\pi}{2}\left[-1+(-1)^r\frac{\Pi\left(\frac{m}{2}\right)\Pi\left(r-\frac{1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)\Pi(r)}\left(\cos\frac{m\pi}{2}+i\sin\frac{m\pi}{2}\right)\right]P_{2r}(x)$$

$$+\Sigma\frac{4r-1}{(m-2r+1)(m+2r)}\cos^2\frac{m\pi}{2}\left[-1+(-1)^{r-1}\frac{\Pi\left(\frac{m-1}{2}\right)\Pi\left(r-\frac{1}{2}\right)}{\Pi\left(\frac{m}{2}\right)\Pi(r-1)}\left(\sin\frac{m\pi}{2}-i\cos\frac{m\pi}{2}\right)\right]P_{2r-1}(x);$$

and subtracting, we find

$$1>x>0,$$

$$0=\Sigma\frac{4r+1}{(m-2r)(m+2r+1)}\sin m\pi\left[-1+(-1)^r\frac{\Pi\left(\frac{m}{2}\right)\Pi\left(r-\frac{1}{2}\right)}{\Pi\left(\frac{m-1}{2}\right)\Pi(r)}\left(\cos\frac{m\pi}{2}+i\sin\frac{m\pi}{2}\right)\right]P_{2r}(x)$$

$$-\Sigma\frac{4r-1}{(m-2r+1)(m+2r)}\sin m\pi\left[-1+(-1)^{r-1}\frac{\Pi\left(\frac{m-1}{2}\right)\Pi\left(r-\frac{1}{2}\right)}{\Pi\left(\frac{m}{2}\right)\Pi(r-1)}\left(\sin\frac{m\pi}{2}-i\cos\frac{m\pi}{2}\right)\right]P_{2r-1}(x).$$

Comparing these with the results already obtained in development of $P_m(x)$, we find a very great reduction, so that the above are equivalent to

$$Q_m(x)=i\frac{\pi}{2}P_m(x)-\sin^2\frac{m\pi}{2}\sum^{n=2r}\frac{2n+1}{(m-n)(m+n+1)}P_n(x)-\cos^2\frac{m\pi}{2}\sum^{n=2r+1}\frac{2n+1}{(m-n)(m+n+1)}P_n(x),$$

and

$$\mathrm{P}_m(x)=\frac{\sin m\pi}{\pi}\sum^{n=2r}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x)-\frac{\sin m\pi}{\pi}\sum^{n=2r+1}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x),$$

where

$$1>x>0;$$

or the equivalent forms,

$$-\sin\frac{m\pi}{2}\sum^{n=2r}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x)=\sin\frac{m\pi}{2}\Big[\mathrm{Q}_m(x)-i\frac{\pi}{2}\mathrm{P}_m(x)\Big]-\cos\frac{m\pi}{2}\ \frac{\pi}{2}\mathrm{P}_m(x),$$

$$-\cos\frac{m\pi}{2}\sum^{n=2r+1}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x)=\cos\frac{m\pi}{2}\Big[\mathrm{Q}_m(x)-i\frac{\pi}{2}\mathrm{P}_m(x)\Big]+\sin\frac{m\pi}{2}\cdot\frac{\pi}{2}\mathrm{P}_m(x).$$

If m is an integer, one of these reduces to the identity

$$\mathrm{P}_m(x)=\mathrm{P}_m(x),$$

while the other gives

$$\mathrm{Q}_m(x)-i\frac{\pi}{2}\mathrm{P}_m(x)=-\sum\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x),$$

where if m is odd, n is even, and *vice versâ*. We may verify this directly without difficulty; for we have *

$$\mathrm{Q}_m(x)=\frac{1}{2}\mathrm{P}_m(x)\log\frac{x+1}{x-1}-\mathrm{Z}_m(x),$$

where

$$\mathrm{Z}_m(x)=2\sum_{n=1\text{ or }0}^{n=m-1}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x),$$

and we find by direct evaluation of the integrals

$$\frac{1}{2}\mathrm{P}_m(x)\log\frac{1+x}{1-x}=-\sum_{n=m+1}^{n=\infty}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x)$$

$$+\sum_{n=1\text{ or }0}^{n=m-1}\frac{2n+1}{(m-n)(m+n+1)}\mathrm{P}_n(x).$$

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* *Cf.* Heine, *Kugelfunctionen*, I. § 27 (20, b, c).

Using the foregoing developments we obtain from the theory of the potential function the theorem that the two expressions

$$(\alpha r^m+\beta r^{-m-1})\begin{matrix}P_m(x)\\Q_m(x)\end{matrix}$$

and

$$\sum_{n=1}^{n=\infty}(\alpha_n r^n+\beta_n r^{-n-1})A_n P_n(x),$$

where A_n is the coefficient just determined, and α_n, β_n are derived from the equations

$$\alpha_n a^n+\beta_n a^{-n-1}=\alpha a^m+\beta a^{-m-1},\ \alpha_n b^n+\beta_n b^{-n-1}=\alpha b^m+\beta b^{-m-1},$$

are equal in value for all values of x and r within the limits

$$1>x>0;\qquad a>r>b.$$

With so much preface I shall freely employ the former expression wherever it appears to be more convenient than the latter.

§ 5. *Numerical.*

In the present section we seek the expression for a motion which is consistent with our theory and with the observations. Since the observations do not determine it uniquely, our steps in the search for it are arbitrary. Let us assume for trial that there is a motion consistent with observation which is separable into two parts, one of which varies as a power of the radius vector, while the other is independent of it. Then, by the preceding theory, we must write the angular motion

$$\omega=A+r^{n-2}\frac{BI_n(x)+CH_n(x)}{1-x^2},$$

where A, B, C are constants;

$$x=\sin\text{ (latitude)}$$

and at the free surface

$$r=1.$$

Now *

$$I_n(1)=0,\ H_n(1)=-\frac{1}{n(n-1)};$$

hence this motion must depart from the observations before the poles are reached, and I have not found values of A, B, C, n which will keep the

* *Phil. Trans.*, 1891, p. 472.

departure within the probable errors of observation from the equator up to 75°. Let us therefore seek values which will cover the observations up to 60° with sufficient accuracy, and those found, consider the problem of correcting the above expression by supplementary terms which will nullify its errors in the higher latitude.

The difficulty of the problem is to assign the best value to n. $n=2$ gives an infinitely slight change with the radius; let us make trial of this as a first approximation. We have

$$\frac{I_2(x)}{1-x^2}=-\frac{1}{2};$$

$$\frac{H_2(x)}{1-x^2}=-\frac{1}{4}\log\frac{1+x}{1-x}-\frac{x}{2(1-x^2)};$$

hence

$n=2$.

Latitude.	$\frac{I_n(x)}{1-x^2}$	$\frac{H_n(x)}{1-x^2}$
0° 24′	$-\cdot5$	$-\cdot0069$
15 0	$-\cdot5$	$-\cdot2711$
30 0	$-\cdot5$	$-\cdot6081$
45 0	$-\cdot5$	$-1\cdot0724$
60 0	$-\cdot5$	$-2\cdot3905$

Hence if $x=A-\cdot5B$, $z=-C$, we have the following equations from Dunér's observations:—

$$14\cdot14=x+\ \cdot0069z;$$
$$13\cdot66=x+\ \cdot2711z;$$
$$13\cdot06=x+\ \cdot6081z;$$
$$11\cdot99=x+1\cdot0724z;$$
$$10\cdot62=x+2\cdot3905z.$$

Treating these after the method of least squares, we get the normal equations

$$63\cdot47=5x+4\cdot3490z;$$
$$49\cdot998=4\cdot3490x+7\cdot3095z;$$

whence

$$x=13\cdot979,\ z=-1\cdot4774;$$

and these substituted in the original equations give the following excesses of the right-hand side over the left :—

$$-\cdot 171,\ -\cdot 082,\ +\cdot 021,\ +\cdot 404,\ -\cdot 173;$$

the mean departure from these from the data being $\pm\cdot 170$, while the accidental error of the observations is about one per cent.* We proceed to improve this agreement by a proper choice of n. We have generally †

$$I_n(x)=\frac{1}{\pi}\int_0^{\pi}(x^2-1)\sin^2\eta(x-\cos\eta\sqrt{x^2-1})^{n-2}d\eta;$$

$$H_n(x)=-\int_0^{\frac{1}{2}\log\frac{x+1}{x-1}}(x^2-1)\sinh^2\phi(x-\cosh\phi\sqrt{x^2-1})^{n-2}d\phi.$$

For $1>x>0$, $H_n(x)$ is complex, but the imaginary part is a multiple of $I_n(x)$. For

$$\log\frac{x+1}{x-1}=i\pi+\log\frac{1+x}{1-x};$$

hence

$$H_n(x)=-\tfrac{1}{2}\int_0^{\frac{1}{2}\log\frac{1+x}{1-x}+i\frac{\pi}{2}}d\phi\sinh^2\phi(x-\sqrt{x^2-1}\cosh\phi)^{n-2};$$

put

$$\phi=\psi+i\frac{\pi}{2},$$

so that

$$\sinh\phi=i\cosh\psi,\ \cosh\phi=i\sinh\psi;$$

then

$$\frac{H_n(x)}{x^2-1}=-\int_0^{\frac{1}{2}\log\frac{1+x}{1-x}}d\psi\cosh^2\psi(x-\sqrt{1-x^2}\sinh\psi)^{n-2}-\int_{-\frac{i\pi}{2}}^{0}d\psi\cosh^2\psi(x-\sqrt{1-x^2}\sinh\psi)^{n-2}.$$

Writing

$$\psi=i\left(\xi-\frac{\pi}{2}\right)$$

in the latter integral, we have

$$i\int_0^{\frac{\pi}{2}}d\xi\sin^2\xi(x+\sqrt{x^2-1}\cos\xi)^{n-2};$$

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* Dunér, *l.c.*

† *Phil. Trans.*, 1891, p. 487.

And it is easily shown

$$\frac{\pi I_n(x)}{x^2-1}=\int_0^{\frac{\pi}{2}} d\xi \sin^2\xi[(x+\sqrt{x^2-1}\cos\xi)^{n-2}+(x-\sqrt{x^2-1}\cos\xi)^{n-2}],$$

which is real; hence

$$H_n(x)-\frac{i\pi}{2}I_n(x)=-\int_0^{\frac{1}{2}\log\frac{1+x}{1-x}}(x^2-1)d\psi\cosh^2\psi(x-\sqrt{1-x^2}\sinh\psi)^{n-2}$$
$$+i\int_0^{\frac{\pi}{2}}(x^2-1)d\xi\sin^2\xi\,.\,\frac{1}{2}[(x+\sqrt{x^2-1}\cos\xi)^{n-2}-(x-\sqrt{x^2-1}\cos\xi)^{n-2}],$$

which is also real; thus the imaginary part of $H_n(x)$ in the expression of p. 26 may be supposed covered by the coefficient B, or omitted. It is the real part which will be denoted by $H_n(x)$ in the remainder of the essay. Thus we find

$$\frac{d}{dn}_{n=2}\left(\frac{I_n(x)}{1-x^2}\right)=\frac{1}{\pi}\int_0^{\frac{\pi}{2}}d\eta\sin^2\eta\log_e[1-(1-x^2)\sin^2\eta];$$

$$\frac{d}{dn}_{n=2}\left(\frac{H_n(x)}{1-x^2}\right)=-\int_0^{\frac{1}{2}\log\frac{1+x}{1-x}}d\psi\cosh^2\psi\log_e[x-\sqrt{1-x^2}\sinh\psi]$$
$$+\int_0^{\frac{\pi}{2}}d\chi\sin^2\chi\tan^{-1}\left(\frac{\sqrt{1-x^2}}{x}\cos\chi\right).$$

To find whether the residual errors indicate a better agreement for $n>2$, or for $n<2$, let us compute these functions.

The computation may be effected by means of GAUSS's method of mechanical quadrature. We write the function to be integrated, say,

$$\int_g^h\psi(x)dx=\frac{h-g}{2}\int_{-1}^{+1}\psi\left(\frac{h+g}{2}+u\frac{h-g}{2}\right)du,$$

and then for an approximate value of what we may call $\int_{-1}^{+1}\phi(u)\,du$, we have

$$A_1\phi(\alpha_1)+A_2\phi(\alpha_2)+\ldots.$$

where $A_1, A_2, \ldots \alpha_1, \alpha_2, \ldots.$ have certain definite values depending upon the number of terms we choose to calculate with. If we take five terms we have

$$\alpha_1=-\alpha_5=\cdot 90618 \qquad \frac{1}{2}A_1=\frac{1}{2}A_5=\cdot 11846$$

$$\alpha_2=-\alpha_4=\cdot 53847 \qquad \frac{1}{2}A_2=\frac{1}{2}A_4=\cdot 23931$$

$$\alpha_3=0 \qquad \frac{1}{2}A_3=\cdot 28444$$

and five computations are to be made for each function for each value of x. I find thus

$n=2$.

Latitude.	$\frac{d}{dn}\left(\frac{I_n'(x)}{1-x^2}\right)$.	$\frac{d}{dn}\left(\frac{H_n(x)}{1-x^2}\right)$.
° ′ 0 24	·57734	·0403 + 1·2270 = 1·2673
15 0	·37843	·5746 + ·6816 = 1·2562
30 0	·22726	1·0426 + ·4610 = 1·5036
45 0	·12216	1·6245 + ·3038 = 1·9283
60 0	·05450	2·7238 + ·1938 = 2·9176

Now if we write $n=2+\epsilon$, and chiefly with a view of finding the sign of ϵ,

$$I_{2+\epsilon}=I_2+\epsilon\left(\frac{dI_n}{dn}\right)_{n=2}, \qquad H_{2+\epsilon}=H_2+\epsilon\left(\frac{dH_n}{dn}\right)_{n=2},$$

we shall have, roughly,

$$\frac{B\epsilon}{1-x^2}\left(\frac{dI_n}{dn}\right)_{n=2}+\frac{C\epsilon}{1-x^2}\left(\frac{dH_n}{dn}\right)_{n=2}=$$

defect of right-hand side from left on p. 29; giving from the first four

$$\begin{aligned}
&\cdot5773\ B\epsilon+1\cdot2673\ C\epsilon=\cdot171\ ;\\
&\cdot3784\ B\epsilon+1\cdot2562\ C\epsilon=\cdot082\ ;\\
&\cdot2273\ B\epsilon+1\cdot5036\ C\epsilon=-\cdot021\ ;\\
&\cdot1222\ B\epsilon+1\cdot9283\ C\epsilon=-\cdot404.
\end{aligned}$$

Up to the present B is arbitrary, C is known, but $C\epsilon$ is arbitrary. Add the first equation to the second, and the third to the fourth:

$$\begin{aligned}
&\cdot9557\ B\epsilon+2\cdot5235\ C\epsilon=\cdot253\ ;\\
&\cdot3495\ B\epsilon+3\cdot4319\ C\epsilon=-\cdot425.
\end{aligned}$$

This gives

$$C\epsilon=-\cdot206\ ;$$

but

$$C=1\cdot4774\ ;$$

therefore

$$\epsilon=-\cdot141.$$

Having thus determined in which direction to pursue the search, let us find the values of A, B, C for the several cases $n=2-\frac{1}{8}$, $2-\frac{1}{4}$, $2-\frac{3}{8}$, $2-\frac{1}{2}$. That

done we shall see that between the limits $n=2$ and $n=2-\frac{1}{2}$, at a value about midway, there is distinct mark of a minimum departure from the data, and also that at this point and its neighbourhood the agreement is close enough for our purposes.

We require the values of I_n and H_n for each value of x, and for each value of n. We first compute $I_{\frac{3}{2}}$ and $H_{\frac{3}{2}}$ *ab initio* by the method already adopted from the formulæ *

$$I_{\frac{3}{2}}(x) = -\frac{2}{\pi}\int_0^{\cos^{-1}x} \sqrt{\{2(\cos\phi - x)\}}\ \cos\phi d\phi,$$

$$H_{\frac{3}{2}}(x) - i\frac{\pi}{2}I_{\frac{3}{2}}(x) = \int_{\cos^{-1}x}^{\pi} \sqrt{\{2(x-\cos\phi)\}}\cos\phi d\phi.$$

We can then find I_{2-m}, H_{2-m}, for $m=\frac{1}{8}, \frac{1}{4}, \frac{3}{8}$ with sufficient accuracy from the formula

$$\phi(2-x) = \phi(2) - x\phi'(2) + \frac{x^2}{1\,.\,2}\phi''(2)$$

in which $\phi(2)$, $\phi'(2)$ have already been calculated, and $\phi''(2)$ is derived from the equation

$$\phi\left(\frac{3}{2}\right) = \phi(2) - \frac{1}{2}\phi'(2) + \frac{1}{8}\phi''(2).$$

Collecting the results, and including the values for $n=1$, which are found immediately, we have the tables :—

Values of $\frac{I_n(x)}{1-x^2}$; $x=\sin$ (latitude) ;

n.	0° 24′.	15°.	30°.	45°.	60°.
2	−·5	−·5	−·5	−·5	−·5
$2-\frac{1}{8}$	−·5707	−·5463	−·5285	−·5155	−·5065
$2-\frac{1}{4}$	−·6383	−·5908	−·5571	−·5314	−·5125
$2-\frac{3}{8}$	−·7027	−·6332	−·5860	−·5477	−·5179
$2-\frac{1}{2}$	−·7646	−·6739	−·6149	−·5645	−·5229
1	−·0070	−·2774	−·6667	−1·4142	−3·4641

* *l.c.*, p. 487.

Values of $\frac{H_n(x)}{1-x^2}$; $x=\sin$ (latitude).

n.	0° 24′.	15°.	30°.	45°.	60°.
2	− ·0069	− ·2711	− ·6081	−1·0724	−2·3905
$2-\frac{1}{8}$	− ·2030	− ·4671	− ·8405	−1·3810	−2·8865
$2-\frac{1}{4}$	− ·4743	− ·7414	−1·1618	−1·8247	−3·6451
$2-\frac{3}{8}$	− ·8210	−1·0936	−1·5720	−2·4036	−4·6664
$2-\frac{1}{2}$	−1·2420	−1·5239	−2·0710	−3·1165	−5·9502
1	−1·0000	−1·0720	−1·3333	−2·0000	−4·0000

We now write observed motion for any latitude

$$=A+\frac{BI_n(x)+CH_n(x)}{1-x^2},$$

and calling

$$A-\cdot 5B=x, \quad -\cdot 01B=y, \quad -C=z.$$

we obtain for each value of n five equations of condition of the type of those on p. 157. Treating each set by the method of least squares, in order to derive the most favourable values for x, y, z, we obtain the results of the annexed table :—

Index.	Coefficients.			Residual Excess over Observations.					
	x.	y.	z.	0° 24′.	15°.	30°.	45°.	60°.	Mean.
2	13·979	...	−1·4774	−·171	−·082	+·021	+·404	−·173	±·170
$2-\frac{1}{8}$	13·296	·1573	− ·9767	+·071	−·092	−·137	+·201	−·041	±·108
$2-\frac{1}{4}$	13·336	·0903	− ·7889	+·070	−·087	−·126	+·190	−·047	±·104
$2-\frac{3}{8}$	13·143	·0782	− ·5741	+·120	−·102	−·146	+·147	−·107	±·106
$2-\frac{1}{2}$	12·532	·0879	− ·3468	+·287	−·127	−·236	+·028	+·049	±·145
1	7·346	−·0520	+4·684	+·454	−·136	−·336	+·003	+·030	±·192

In examining the residuals shown by this table, it must be remembered that in the first case we have one coefficient less to dispose of than in the others, so that the index 2 is nearer the truth than the mean ±·170 would indicate.

Again, for the last two cases the agreement is worst in the lower latitudes, whereas we would prefer an expression with the contrary feature; hence the residuals $\pm\cdot145$ and $\pm\cdot192$ underrate the measure of the errors for indices $2-\frac{1}{2}$ and 1 respectively.

As we have already remarked, the probable error of the observations is about 1 per cent., which is well without the mean excesses for index $2-\frac{1}{4}$. Hence, crude as the assumption is with which we began this section, we see that a single term varying with the radius vector may cover all important elements of change for 60° from the equator.

Let us next consider the errors nearer the poles. At latitude 74° 48′ the motion given by any of the better formulæ is some 5° below observation; higher still it vanishes, and, changing sign, tends to $-\infty$ at the poles. To complete the solution as we have begun it, we must add to the original expression supplementary terms which shall remove remaining errors, excluding from view a polar cone so narrow that, whatever possible motion we attribute to it, it cannot sensibly modify the motion of the whole. But this would be idle labour.

For in the first place the data themselves are somewhat precarious; DUNÉR's observations differ greatly from CARRINGTON's; we cannot be sure to what level of the Sun's body either set refers; we have made no allowance for the turmoil of the immediate outward surfaces—though this being chiefly in the direction of the radius cannot greatly affect the motion in azimuth which we are now considering. Clearly we are not justified in founding any elaborate structure upon our knowledge; and secondly, it seems that if the motion

$$\omega = A + r^{n-2}\frac{BI_n(x) + CH_n(x)}{1-x^2}$$

were artificially set up, it would in all probability finally supply a state indistinguishable from the observed; for though this is a "steady motion," if set up initially it would not be permanent; the great velocities in high latitudes would bring discontinuity, and this would modify somewhat the final distribution of motion in the entire body. To make some estimate of the degree of this modification let us calculate the moment of momentum of any cone surrounding the pole.

Let $x=\sin$ (latitude) as before; then the moment of momentum of any cone

$$=4\pi\int_0^a\int_0^{\cos^{-1}x} dr d\theta r^2 \sin\theta \,.\, r^2 \sin^2\theta\, \omega$$

$$=4\pi\int_0^a\int_x^1 dr dx \,.\, r^4(1-x^2)\omega$$

—where
$$\omega=\mathrm{A}+\left(\frac{r}{a}\right)^{n-2}\frac{\mathrm{BI}_n(x)+\mathrm{CH}_n(x)}{1-x^2}$$

$$=\frac{4\pi a^5}{15}\Bigg[\mathrm{A}(3x-x^3)+\frac{15}{(n+3)(2n-1)}\mathrm{B}\Big(\mathrm{I}_{n+1}(x)-\mathrm{I}_{n-1}(x)\Big)$$
$$+\frac{15}{(n+3)(2n-1)}\mathrm{C}\Big(\mathrm{H}_{n+1}(x)-\mathrm{H}_{n-1}(x)\Big)\Bigg]_x^1$$

since *

$$(2n-1)\int \mathrm{I}_n dx=\mathrm{I}_{n+1}-\mathrm{I}_{n-1},$$

$$(2n-1)\int \mathrm{H}_n dx=\mathrm{H}_{n+1}-\mathrm{H}_{n-1}.$$

To avoid fresh calculations of the difficult functions I_n and H_n, let us take $n=2$, which we have seen is not far astray. It happens that for this case the integral of H_n is an exception, but its value is obtained without difficulty. We find the moment of momentum from poles to latitude $\sin^{-1} x$

$$=\frac{4\pi}{15}a^5\Bigg\{(\mathrm{A}-\cdot 5\mathrm{B})(1-x)^2(2+x)$$
$$+\mathrm{C}\Big[-\frac{1}{2}-\log_e 2+\frac{x^2}{2}+\frac{1}{4}(1+x)^2(2-x)\log_e(1+x)+\frac{1}{4}(1-x)^2(2+x)\log_e(1-x)\Big]\Bigg\}.$$

Now

$$\mathrm{A}-.5\mathrm{B}=13\cdot979, \qquad \mathrm{C}=1\cdot4774.$$

Hence the moment of momentum of the whole

$$=\frac{4\pi}{15}a^5\times 26\cdot 195,$$

the unit of angular velocity being a degree per day.

* *l.c.*, p. 461 (19).

The above expression vanishes at latitude 65° 30′—a point at which our formulæ are about 1°·1 below DUNÉR's. Thus in the final state of motion, a cone of 24° 30′ surrounding the poles must borrow from the whole body enough momentum to carry it (upon the average) something less than 10° per day. If we say 10°, the moment of momentum is

$$=\frac{4\pi}{15}a^5\times 0{\cdot}234,$$

or $\frac{1}{112}$ of the whole—a fraction which is not far from the measure of the uncertainty of the observations.

Thus the errors involved in the formula hitherto used are not so serious that their removal would outweigh any loss of simplicity.

Hence without further refinements we write the angular motion at any point

$$\omega=\omega_0+r^{n-2}(\Omega-\omega_0),$$

where Ω is the observed surface motion at the same latitude, and ω_0 is a constant, viz. $x-50y$; so that for

$n=2$,	ω_0=indeterminate
$2-\frac{1}{8}$	5°·431
$2-\frac{1}{4}$	8·821
$2-\frac{3}{8}$	9·233
$2-\frac{1}{2}$	8·137

The table on the following page shows the value of the angular motion at any point of the body for each of the last four values of n.

Fraction of Radius.	Index.	Daily Angular Motion in Degrees				
		0° 24′.	15°.	30°.	45°.	60°.
1		14°·14	13°·66	13°·06	11°·99	10°·62
$\frac{7}{8}$	$n=2-\frac{1}{8}$	14·29	13·80	13·19	12·10	10·71
	$2-\frac{1}{4}$	14·32	13·82	13·20	12·10	10·68
	$2-\frac{3}{8}$	14·39	13·89	13·26	12·13	10·69
	$2-\frac{1}{2}$	14·53	14·04	13·40	12·26	10·79
$\frac{3}{4}$	$2-\frac{1}{8}$	14·46	13·96	13·34	12·23	10·81
	$2-\frac{1}{4}$	14·54	14·02	13·38	12·23	10·75
	$2-\frac{3}{8}$	14·70	14·16	13·49	12·30	10·77
	$2-\frac{1}{2}$	15·07	14·51	13·82	12·59	11·00
$\frac{5}{8}$	$2-\frac{1}{8}$	14·67	14·16	13·52	12·39	10·93
	$2-\frac{1}{4}$	14·80	14·26	13·59	12·39	10·84
	$2-\frac{3}{8}$	15·08	14·51	13·79	12·52	10·88
	$2-\frac{1}{2}$	15·73	15·12	14·36	13·01	11·28
$\frac{1}{2}$	$2-\frac{1}{8}$	14·93	14·40	13·75	12·58	11·09
	$2-\frac{1}{4}$	15·14	14·57	13·86	12·59	10·96
	$2-\frac{3}{8}$	15·59	14·97	14·19	12·81	11·02
	$2-\frac{1}{2}$	16·63	15·94	15·10	13·59	11·65
$\frac{3}{8}$	$2-\frac{1}{8}$	15·28	14·73	14·05	12·85	11·30
	$2-\frac{1}{4}$	15·62	15·00	14·24	12·87	11·12
	$2-\frac{3}{8}$	16·32	15·62	14·76	13·21	11·23
	$2-\frac{1}{2}$	17·94	17·15	16·18	14·43	12·19
$\frac{1}{4}$	$2-\frac{1}{8}$	15·79	15·22	14·50	13·23	11·60
	$2-\frac{1}{4}$	16·34	15·66	14·82	13·30	11·37
	$2-\frac{3}{8}$	17·48	16·68	15·67	13·87	11·56
	$2-\frac{1}{2}$	20·14	19·18	17·98	15·84	13·10
$\frac{1}{8}$	$2-\frac{1}{8}$	16·72	16·10	15·32	13·94	12·16
	$2-\frac{1}{4}$	17·77	16·96	15·95	14·15	11·85
	$2-\frac{3}{8}$	19·93	18·89	17·58	15·23	12·26
	$2-\frac{1}{2}$	25·11	23·76	22·06	19·03	15·16
$\frac{1}{16}$	$2-\frac{1}{8}$	17·74	17·06	16·21	14·70	12·77
	$2-\frac{1}{4}$	19·46	18·50	17·30	15·16	12·42
	$2-\frac{3}{8}$	23·11	21·75	20·05	17·03	13·15
	$2-\frac{1}{2}$	32·15	30·22	27·82	23·54	18·06

The figures below are drawings of the curves of equal angular velocity for two cases, interpolated graphically from the above table.

With respect to these results, we remark that, although it was our aim to find a motion that increased inwards along any radius, we have not succeeded in the foregoing analysis in embodying any condition except that it shall not increase in some parts and decrease in others, and we must regard it as a favourable coincidence that the result is such as we wished to find.

On concluding these numerical researches, let us briefly review what we have proved. We have found what we proposed to find on p. 159—an expression of simple form, satisfying the conditions of theory as expressed by the differential equations, agreeing with the surface observations within their own probable errors, and also (accidentally) embodying the condition that the angular motion increases inwards along all radii. This is one possible state of motion consistent with fact and with our theory. That is to say, we have shown—to my judgment, beyond any doubt—that such a body as the Sun could move for long ages with such a surface motion as the observed, and a motion of its body at any point within the limits of the greatest and least motions shown at that point by our last table. Of these motions we prefer that associated with the index $2-\frac{1}{4}$, and $2-\frac{1}{2}$ gives a rate of increase almost certainly too great. But it cannot be asserted that anywhere within their limits is there reason for casting doubt upon the sufficiency and reasonableness of the causes originally assigned.

Conversely, admitting only that the Sun is a body subject in its internal motions to the differential equations of § 3, with what precision may we now define its necessary motions ! We must supplement the possible motion we have found by a series of terms expressing a motion which vanishes at the outward surface, and is arbitrary at any surface within. That is to say, the Sun's internal motions are of necessity expressed by

$$\omega=\omega_0+r^{n-2}(\dot{\Omega}-\omega_0)+\sum_{m=0}^{m=\infty}(r^{m-2}-r^{-m-1})\mathrm{A}_m\mathrm{I}_m(x)/(1-x^2),$$

where m is a positive integer. Beyond this point we cannot go by strict reasoning, but it may easily be seen that to attach any finite value to A_m for any value of m involves a state of motion which is highly improbable. Both direct and indirect evidence of the strongest kind forbids us to believe that the Sun's development has reached a term ; and just as we observe relative motions

at his surface, we must expect to find them within his body; but the two must be comparable in magnitude, such as those shown in our table. For example, for $n=2-\frac{1}{4}$, at about a radius-length along the surface, the motion decreases $3^{\circ}\cdot52$, and inwards it increases $5^{\circ}\cdot22$. Now A_0 or A_1 finite gives a

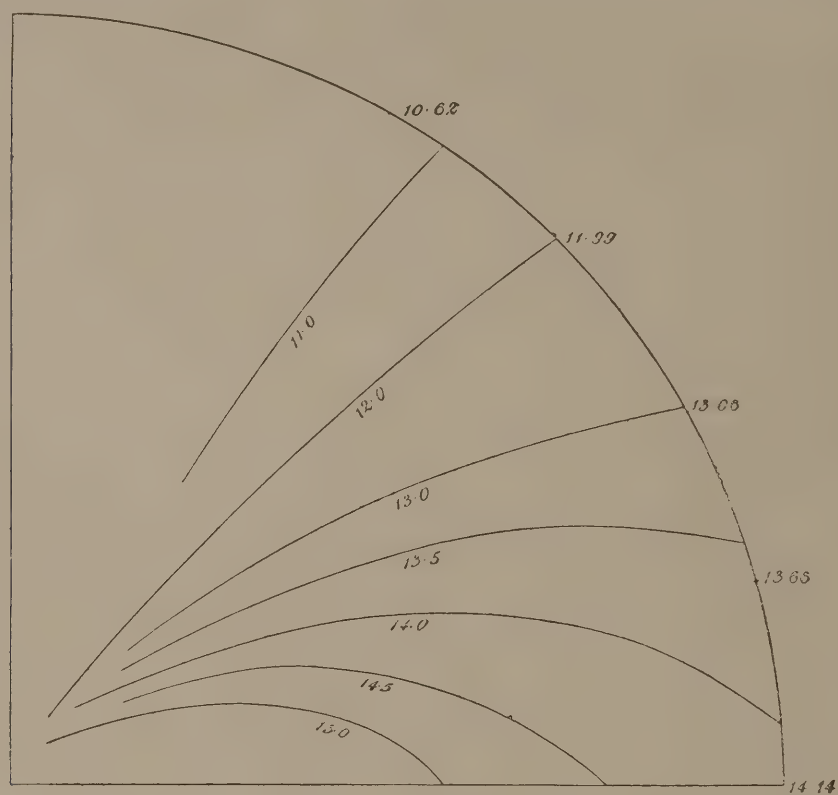

Fig. 4.

Curves of equal angular motion: $n = 2 - \frac{1}{4}$.

finite part of the motion varying as r^{-2}, and any other finite coefficient gives a still higher rate. When we consider that the Sun's internal motions have been levelled by friction throughout countless ages, it seems impossible that any sensible trace of so rapid a rate of change should be still remaining; and though, if many of the coefficients A are finite, they may happen to neutralise one another, it remains true that the added terms which vanish at the outer surface are inadmissible when they increase inwards rapidly, and insignificant when they do not.

Therefore we have shown that there is a state of motion consistent with theory and fact which is nearly given by the numbers in the table of p. 176; and, further, that this is the only such motion not involving high improbability.

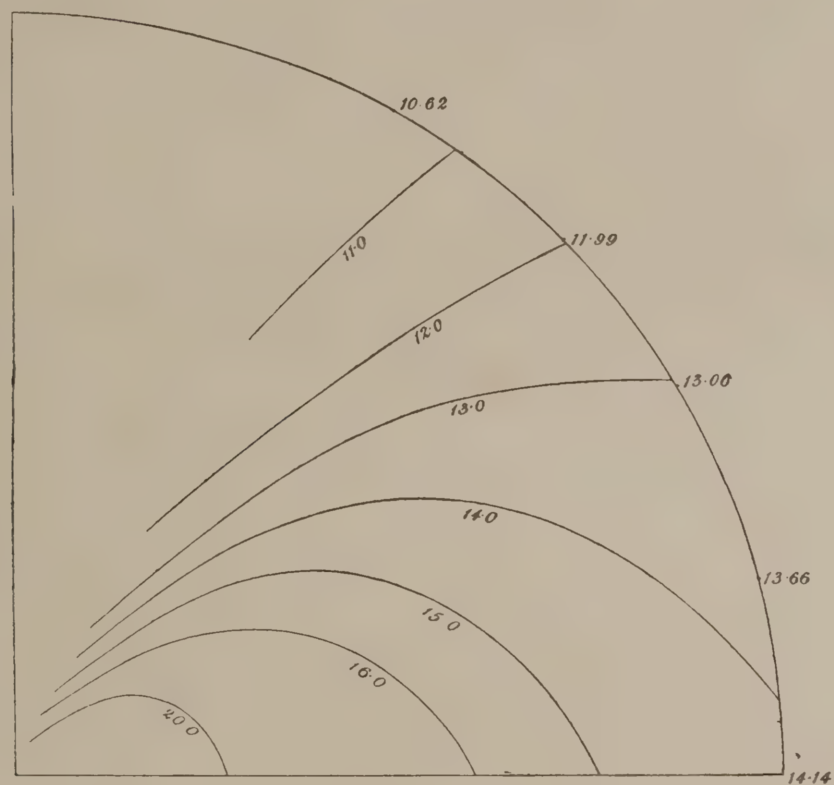

Fig. 5.

Curves of equal angular motion $n = 2 - \frac{1}{2}$.

§ 6. *Motion in Latitude.*

Let us now return to the equations of motion of § 2, to examine the associated motion in latitude.

As before, differential coefficients with respect to t and θ may be omitted; v^2, u, w, δ are of the second, that is, lowest, order in the angular motion, so

that any multipliers of these may be considered constant or functions of r alone, as the case may be. Hence the equations become

$$\frac{d}{d\varpi}(\rho\varpi u)+\varpi\frac{d}{dz}(\rho w)=0$$

$$-\frac{v^2}{\varpi}=\frac{dQ}{d\varpi}+\frac{\mu}{3\rho}\frac{d\delta}{d\varpi}+\frac{\mu}{\rho}\left(\nabla^2 u-\frac{u}{\varpi^2}\right)+\frac{1}{\rho}\frac{d\mu}{dr}\left[-\frac{2}{3}\delta\frac{\varpi}{r}+2\frac{du}{d\varpi}\frac{\varpi}{r}+\frac{du}{dz}\frac{z}{r}+\frac{dw}{d\varpi}\frac{z}{r}\right];$$

$$0=\frac{dQ}{dz}+\frac{\mu}{3\rho}\frac{d\delta}{dz}+\frac{\mu}{\rho}\nabla^2 w+\frac{1}{\rho}\frac{d\mu}{dr}\left[-\frac{2}{3}\delta\frac{z}{r}+2\frac{dw}{dz}\frac{z}{r}+\frac{du}{dz}\frac{\varpi}{r}+\frac{dw}{d\varpi}\frac{\varpi}{r}\right];$$

$$\delta=\frac{du}{d\varpi}+\frac{dw}{dz}+\frac{u}{\varpi}.$$

The equation of continuity shows that we may assume

$$u=\frac{1}{\varpi\rho}\frac{d\psi}{dz},\quad w=-\frac{1}{\varpi\rho}\frac{d\psi}{d\varpi},$$

and ρ is a function of r alone; the function ψ has an obvious relation to STOKES's Current Function, for $2\pi\psi$ represents the flux of matter per unit time through a parallel of latitude. The velocity in latitude towards the pole is

$$U=-\frac{1}{\varpi\rho}\frac{d\psi}{dr};$$

and in radius vector, outwards,

$$W=\frac{1}{\varpi\rho}\left[-\frac{z}{r}\frac{d\psi}{d\varpi}+\frac{\varpi}{r}\frac{d\psi}{dz}\right]=-\frac{\rho}{\rho'}\delta,$$

denoting

$$\frac{d\rho}{dr}\text{ by }\rho'.$$

The discussion now divides into two parts: the first concerns the internal parts where pressure, temperature, and density are almost constant, and the second the neighbourhood of the outer surface where these quantities decrease with great rapidity.

Assuming them to be constant, we get an equation for ψ by eliminating Q; namely,

$$\delta=0$$

$$-\frac{d}{dz}\left(\frac{v^2}{\varpi}\right)=\frac{\mu}{\rho^2}\left[\left(\frac{d^2}{dz^2}+\frac{d^2}{d\varpi^2}+\frac{1}{\varpi}\frac{d}{d\varpi}\right)\frac{1}{\varpi}\left(\frac{d^2\psi}{dz^2}+\frac{d^2\psi}{d\varpi^2}-\frac{1}{\varpi}\frac{d\psi}{d\varpi}\right)-\frac{1}{\varpi^3}\frac{d\psi}{dz}\right].$$

This equation shows that besides the motions in latitude and radius vector which are consequent upon a given angular motion about the axis of z, there is an immense variety of such motions which are entirely independent of rotation ; to find the former we require a particular integral corresponding to the known value of the left-hand member, and to find the latter we require the general solution when the left-hand member is zero ; but it does not appear that the interest of these results could repay the difficulties of attaining them.

Near the surface the case is different, for there we have records of observed motions ; and it happens that, if we suppose any such state to exist as convective equilibrium of temperature would maintain, the equations give us just the information we seek without any integration at all.

Let us suppose that close to the surface

$$\mu \propto (a-r)^m, \quad \rho \propto (a-r)^n ;$$

then it is obvious that ultimately only those terms will be of importance which are multiplied by the highest differential coefficients of μ and ρ. Let us simplify the equations by leaving out all others ; denote differentiations with respect to r by dashes, and let $\sigma = \frac{1}{\rho}$. Then

$$\frac{du}{d\varpi} = \sigma' \frac{\varpi}{r} \frac{1}{\varpi} \frac{d\psi}{dz}, \quad \frac{du}{dz} = \sigma' \frac{z}{r} \frac{1}{\varpi} \frac{d\psi}{dz}, \text{ \&c.};$$

so that

$$-\frac{v^2}{\varpi} = \frac{dQ}{dw} + \frac{\mu\sigma}{3} \frac{d\delta}{d\varpi} + \mu\sigma\left(\nabla^2 u - \frac{u}{\varpi^2}\right) + \mu'\sigma\left(\frac{1}{3} \frac{\varpi}{r}\delta + \frac{\sigma'}{\varpi} \frac{d\psi}{dz}\right);$$

$$0 = \frac{dQ}{dz} + \frac{\mu\sigma}{3} \frac{d\delta}{dz} + \mu\sigma\nabla^2 w + \mu'\sigma\left(\frac{1}{3} \frac{z}{r}\delta - \frac{\sigma'}{\varpi} \frac{d\psi}{d\varpi}\right).$$

Eliminate Q ;

$$-\frac{d}{dz}\left(\frac{v^2}{\varpi}\right) = \frac{1}{3}(\mu\sigma)'\left(\frac{z}{r} \frac{d\delta}{d\varpi} - \frac{\varpi}{r} \frac{d\delta}{dz}\right) + (\mu\sigma)'\left[\frac{z}{r}\left(\nabla^2 u - \frac{u}{\varpi^2}\right) - \frac{\varpi}{r}\nabla^2 w\right] + \mu'\sigma\left[\frac{1}{3}\left(\frac{\varpi}{r} \frac{d\delta}{dz} - \frac{z}{r} \frac{d\delta}{d\varpi}\right)\right.$$
$$\left. + \frac{\sigma''}{\varpi}\left(\frac{z}{r} \frac{d\psi}{dz} + \frac{\varpi}{r} \frac{d\psi}{d\varpi}\right) + \frac{\sigma'}{\varpi}\left(\frac{d^2\psi}{d\varpi^2} + \frac{d^2\psi}{dz^2} - \frac{1}{\varpi} \frac{d\psi}{d\varpi}\right)\right]$$
$$+ (\mu'\sigma)'\sigma' \frac{1}{\varpi}\left(\frac{z}{r} \frac{d\psi}{dz} + \frac{\varpi}{r} \frac{d\psi}{d\varpi}\right).$$

In this equation

$$\sigma'\left(\frac{d^2\psi}{d\varpi^2}+\frac{d^2\psi}{dz^2}-\frac{1}{\varpi}\frac{d\psi}{d\varpi}\right)$$

may be omitted as of lower order than the rest;

$$\nabla^2 u=\frac{\sigma''}{\varpi}\frac{d\psi}{dz};\quad \nabla^2 w=-\frac{\sigma''}{\varpi}\frac{d\psi}{d\varpi}$$

And since

$$\delta=\frac{\rho'}{\rho}\mathrm{W},$$

therefore

$$\frac{d\delta}{d\varpi}=-\left(\frac{\sigma'}{\sigma}\right)'\mathrm{W}\frac{\varpi}{r},\quad \frac{d\delta}{dr}=-\left(\frac{\sigma'}{\sigma}\right)\mathrm{W}\frac{z}{r}$$

so that

$$\frac{z}{r}\frac{d\delta}{d\varpi}-\frac{\varpi}{r}\frac{d\delta}{dz}=0,$$

that is to say, W disappears. Finally

$$\frac{1}{\varpi}\left(\frac{z}{r}\frac{d\psi}{dz}+\frac{\varpi}{r}\frac{d\psi}{d\varpi}\right)=\frac{1}{\varpi}\frac{d\psi}{dr}=-\rho\mathrm{U};$$

therefore

$$\frac{d}{dz}\left(\frac{v^2}{\varpi}\right)=\mathrm{U}\left[\frac{1}{\sigma}(\mu\sigma)'\sigma''+\mu'\sigma''+\frac{\sigma'}{\sigma}(\mu'\sigma)'\right]$$
$$=\rho\mathrm{U}[(\mu\sigma)'\sigma''+(\mu'\sigma\sigma')'].$$

Now with the supposition we have made, the expression in [] is a positive multiple of

$$\{n(n+1)-3m(n+1)+m^2\}(a-r)^{m-n-3};$$

if

$$n=\frac{3m-1}{2}\pm\frac{1}{2}\sqrt{5m^2+6m+1},$$

this vanishes; and if n lies between these limits, it is negative. Now for convective equilibrium, taking μ proportional to the absolute temperature, and

$$\gamma=1{\cdot}4,$$

we have

$$m=1,\ n=2\tfrac{1}{2}$$

whereas the limits are

$$1\pm\sqrt{3}.$$

Hence

$$U = \frac{d}{dz}\left(\frac{v^2}{\varpi}\right) \times \text{a small negative factor.}$$

But

$$\frac{d}{dz}\left(\frac{v^2}{\varpi}\right) = 2\varpi\omega\frac{d\omega}{dz},$$

where ω is the angular velocity, and

$$\omega\frac{d\omega}{dz}$$

is negative, and has a numerical maximum in the middle latitudes; hence we find the last stage of the motion in latitude is a slight upward drift, becoming more distinct in the middle latitudes.

CARRINGTON observed* a distinct drift towards the pole in latitude greater than 20°, and a feeble tendency towards the equator in latitudes between 10° and 20°, below which no reliable motion appeared to exist. The former observation has been confirmed by Mr. LOCKYER,† who observed "proper motions" in spots for the years 1878–9, and found in many cases that the spots drift polewards. It appears from our theory that there may well be some uncertainty.

* *Observations of Solar Spots*, p. 222.

† *Chemistry of the Sun*, p. 433.

Index Catalogue of Nebulæ found in the Years 1888 *to* 1894, *with Notes and Corrections to the New General Catalogue.* By J. L. E. Dreyer, Ph.D.

[Received Jan. 10; read Jan. 11, 1895.]

The *New General Catalogue* contains the places and descriptions of all the nebulæ known at the end of the year 1887. In the following catalogue I have put together all the new nebulæ of which the places and descriptions have been published since then and up to the end of 1894. Most of these objects are very faint and minute, and doubtless represent but a very small part of the innumerable host of similar objects which are within the reach of our largest telescopes, while not a few of those found with moderate-sized instruments will probably turn out to be nothing but two or three very faint stars close together. But although the majority of these new nebulæ cannot compare in interest with those catalogued in earlier years, it seems useful to have their places readily accessible in an index catalogue, though the number of observers to whom this will be of use will naturally be a comparatively limited one.

The catalogue is arranged exactly like the *New General Catalogue*, and requires but little explanation. The names of the observers will be found in the second column. A high number in brackets, *e.g.* (3259), denotes the number of the *Astronomische Nachrichten*, where the account of the finding of the object is recorded. The other references are as follow:

B. is Bigourdan's second list, *Comptes Rendus*, March and April 1891. Numbers below 102 refer to his first list (*ibid.*, November and December 1887), a few objects from which are not in the *New General Catalogue*.

Burnham. See *Publications of the Lick Observatory*, vol. ii.

Denning. *Monthly Notices*, vol. li. p. 96, and a privately communicated list, in which some of the positions in the printed list had been corrected.

Espin. See *Monthly Notices*, vol. liv. p. 327.

J. refers to M. Javelle's two lists of 807 new nebulæ found with the great equatorial of 30 inches aperture at the Nice Observatory (*Annales*, T. iv. and T. vi.). The positions are micrometrically determined.

Kobold. See *Astr. Nachr.*, No. 3184.

O. St. refers to the Publications of the Leander McCormick Observatory, Part 6 (southern Nebulæ, micrometric observations).

Pickering. See *Annals of Harvard College Observatory*, vol. xviii., where a list of objects discovered by photography is given.

Sf. refers to the list of objects found by Professor Safford, and given in an appendix to the *New General Catalogue.* I have inserted them here (though found before 1888), as very few people ever think of referring to an appendix.

Spitaler. See *Astr. Nachr.*, Nos. 3167–68. The positions are micrometrically determined.

Sw. refers to Mr. Lewis Swift's four lists of nebulæ found at the Warner Observatory, Rochester, N.Y.

VII.	*Astr. Nachr.*	2859.
VIII.	,, ,,	2918.
IX.	,, ,,	3004.
X.	,, ,,	3094.
(X.)	A few objects in *Monthly Notices*, vol. liii. p. 273.	

The positions of these objects are generally reliable within one or two minutes of arc, but larger errors occur occasionally, and, as Mr. Swift rarely mentions whether he has seen other nebulæ in the neighbourhood of the supposed new ones, it is generally very difficult to be certain that the latter are not identical with old ones. The absence of estimations of magnitudes and distances of the stars mentioned as being near the observed nebulæ is also to be regretted.

THOME refers to some nebulæ picked off the charts of the Cordoba Durchmusterung.

With regard to the descriptions of the objects it will be necessary for observers to bear in mind the aperture of the instrument with which each object has been found, as a comparison between the descriptions of the same nebula found by Mr. SWIFT with a 16-inch refractor, and by Dr. SPITALER with a 27-inch, or M. JAVELLE with a 30-inch, shows that the first-mentioned observer always describes it as much fainter than the others do, as is only natural.

Two clusters in MESSIER's catalogue do not occur in the *New General Catalogue*, and may perhaps be mentioned here. They are (for 1860) :

M. 25	18^h	23^m	17^s	109°	2′·0	Cl of S st.
M. 48	8	6	54	91	32·1	Cl of S st.

I have inserted in the catalogue a few very extensive and diffused nebulosities detected by means of photography by Mr. BARNARD and Professor MAX WOLF. The fifty-two regions found by WILLIAM HERSCHEL to be more or less "affected with nebulosity" ought to be re-examined by means of photography. Their places are given in the *Phil. Trans.* for 1811, p. 275, and in AUWERS' catalogue of W. HERSCHEL's nebulæ (*Königsberger Beobachtungen*, xxxiv. p. 199).

At the end of the catalogue I have given some notes and corrections to the *New General Catalogue*, relating chiefly to objects the places of which have been more accurately determined during recent years. Much valuable work has been done in this direction by Dr. SPITALER and Mr. BURNHAM, but there are still many doubtful cases to be examined by the possessors of large telescopes, and it is much to be hoped that some of these may turn their attention from the finding of new "eeF, eS" nebulæ to the less showy but more useful work of verifying the many old nebulæ which require re-observation.

Index Catalogue of Nebulæ, 1888 to 1894.

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1	B. 103	0 1 15	+3·07	63 4	−20·1	D*, 13 & 13, one nebs
2	J. 1	0 3 52	3·06	103 36·2	20·1	F, S, bM
3	J. 2	0 4 56	3·07	91 12·1	20·1	F, vS, iF, r
4	Pechüle (3259)	0 6 15	3·08	73 20·6	20·0	vF, vS, R
5	J. 3	0 10 27	3·06	100 19·1	20·0	F, neb * 13m
6	J. 4	0 11 46	3·07	94 3·2	20·0	F, vS, R, mbM = * 14
7	J. 506	0 11 51	3·09	80 13·8	20·0	F, vS, R, * 12·5 close
8	Sf. 89 J. 5	0 11 54	3·07	93 59·9	20·0	vF, vS, irr E, lbM
9	J. 6	0 12 37	3·05	104 54·1	20·0	vF, pL, R
10	Sw. VII.	0 12 44·	3·20	31 28	20·0	F * inv in eF, vL neb
11	Barnard	0 13 0±	3·19	34 11	20·0	vF, L, triple * on np corner
12	J. 7	0 13 6	3·07	93 26·2	20·0	pF, S, Ens
13	J. 507	0 13 8	3·08	83 4·9	20·0	vF, pL, Ens, dif
14	B. 104	0 15 22	3·09	80 18	20·0	Susp neb
15	J. 8	0 20 48	3·07	90 50·7	20·0	vF, vS, iF, sbM
16	J. 9	0 21 2	3·04	103 52·6	20·0	pB, R, bM
17	J. 10	0 21 18	3·07	88 7·8	20·0	pB, vS, R, stellar
18	J. 11	0 21 29	3·04	102 21·6	20·0	pF, S, iF, gbM
19	J. 12	0 21 33	3·04	102 24·9	20·0	R, S, stellar = 14m
20	J. 13	0 21 35	3·04	103 47·5	20·0	pB, R
21	J. 14	0 22 1	3·07	90 56·3	20·0	pB, vS, iF
22	J. 15	0 22 27	3·05	99 51·5	20·0	F, S, lbM, r
23	J. 16	0 23 47	3·04	103 30·4	19·9	pB, S, R, bM
24	B. 105	0 23 51	3·16	59 56	19·9	S, Cl, 30″–40′, nebs?
25	J. 17	0 24 3	3·07	91 10·1	19·9	F, vS, irrR, vlbM, r
26	J. 18	0 24 41	3·03	104 6·8	19·9	F, S, R, gbM
27	J. 19	0 26 2	3·03	104 8·8	19·9	F, vS, lEpf, bM
28	J. 20	0 26 4	3·03	104 13·7	19·9	vF, dif, vlbM
29	J. 21	0 27 1	3·06	92 57·2	19·9	vF, S, R, lbM
30	J. 22	0 27 5	3·06	92 51·5	19·9	vF, S, R, lbM
31	J. 508	0 27 9	3·10	78 30·1	19·9	F, Epf, dif
32	J. 23	0 27 52	3·06	92 55·2	19·9	vF, vS, R, lbM
33	J. 24	0 27 56	3·06	92 54·8	19·9	vF, vS, R, lbM
34	Sf. 97, Sw. IX.	0 28 22	3·10	81 38·3	19·9	vF, pS, lE
35	J. 509	0 30 26	3·10	80 24·8	19·9	vF, S, dif, * 9·5 nf
36	J. 25	0 30 47	3·02	106 12·6	19·9	F, vS, R, dif
37	J. 26	0 31 32	3·02	106 8·1	19·8	eF, vS, R, dif
38	J. 27	0 31 37	3·02	106 11·8	19·8	F, S, R
39	J. 28	0 32 5	3·02	104 56·4	19·8	pB, pL, Ens, gbM
40	J. 510	0 32 12	+3·08	88 18·6	−19·8	F, S, R, gbMN = 13·5

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
41	J. 29	0 32 38	+3·02	104 56·6	−19·8	vF, S, dif
42	J. 30	0 34 4	3·01	106 11·8	19·8	S, irr, v dif
43	B. 106	0 34 52	3·18	61 7	19·8	vF, S, mbM
44	Sw. X.	0 35 8	3·07	89 53·5	19·8	eF, S, R, bet 2 st
45	B. 107	0 35 12	3·18	61 6	19·8	Susp neb
46	J. 511	0 35 31	3·17	63 31·0	19·8	pB, S, R, bM
47	J. 31	0 35 53	3·02	104 30·8	19·8	eF, eS, R, stellar
48	Barnard (3097)	0 36 31	3·03	98 38·9	19·8	pF, S (? var brightness)
49	Sw. X.	0 36 43	3·08	88 54·6	19·8	eeF, pS, R, e diffic
50	J. 32	0 39 3	3·03	100 15·9	19·8	F, = neb ✱ 13
51	J. 33	0 39 22	3·01	104 12·3	19·8	pB, S, bM, r
52	J. 34	0 41 9	3·09	86 40·8	19·7	vF, vS, R, gvlbM
53	Sw. X.	0 43 11	3·12	80 8·6	19·7	eeF. pS, R, others susp
54	Spitaler (2993)	0 43 38	3·06	93 3·3	19·7	Neb or S Cl, 2′. bM
55	J. 512	0 44 27	3·11	83 2·6	19·7	F, vS, dif, ✱ 13 close
56	J. 35	0 44 29	3·01	103 36·1	19·7	vF, S, lbM
57	J. 513	0 47 31	3·13	78 55·4	19·6	F, vS, R, vlbM, F ✱ close
58	J. 36	0 48 2	3·00	104 26·5	19·6	F, vS, R, r
59	{M. Wolf (3214) Barnard}	0 49 0 ±	3·6	29 40	19·6	pF, eL ! (nf γ Cassiop)
60	J. 37	0 49 5	3·00	104 7·7	19·6	F, vS, R, SN
61	J. 514	0 49 50	3·11	83 15·4	19·6	pF, vS, R, vlbM
62	J. 515	0 51 24	3·13	78 57·0	19·5	vF, pL, dif
63	{Barnard M. Wolf (3214)}	0 51 50 ±	3·6	29 55	19·5	pF, eL ! conn with np one
64	J. 516	0 51 51	3·22	63 42·2	19·5	F, S, R, gmbM
65	Sw. X.	0 52 53	3·41	43 4·2	19·5	eF, pL, mE, Bst f & s
66	B. 108	0 52 56	3·25	59 58	19·5	vF, vS, irr
67	B. 109	0 53 14	3·03	97 40	19·5	vF, suspected
68	B. 110	0 53 18	3·03	97 42	19·5	vF, suspected
69	Sf. 66	0 53 48	3·26	59 40·9	19·5	F, iF, lbM
70	J. 38	0 53 54	3·07	90 42·4	19·5	vF, vS, lbM
71	B. 111	0 54 14	3·03	97 32	19·5	vF, suspected
72	B. 112	0 54 28	3·03	97 31	19·5	Neb ; ✱ 7 sf 2′
73	J. 39	0 57 40	3·10	85 58·7	19·4	vF, pL, dif
74	J. 40	0 58 42	3·09	86 38·7	19·4	vF, S, stellar
75	J. 517	0 59 51	3·13	79 55·0	19·4	vF, vS, dif, vlbM
76	J. 518	1 1 6	3·04	95 18·3	19·3	F, vS, R, lbM
77	J. 41	1 1 48	2·97	106 10·2	19·3	vF, S, irr, bM
78	J. 42	1 1 52	2·97	106 35·4	19·3	F, S, lbM, r
79	J. 43	1 1 54	2·97	106 41·7	19·3	R, S, bM N = 14m
80	J. 44	1 1 56	+2·97	106 9·2	−19·3	vF, S, R, gbM

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
81	Sw. VII.	1 2 3	+3·06	92 26·1	−19·3	eF, S, lE, ✱ close nf
82	J. 45	1 2 11	2·97	106 44·7	19·3	F, S, gbM
83	J. 46	1 3 15	3·08	89 2·3	19·3	F, S, dif, lbM
84	J. 47	1 4 11	3·08	89 5·3	19·2	pB, S, iF, bM
85	B. 113	1 4 37	3·06	91 13	19·2	eF, close to ✱ 8
86	J. 48	1 6 36	3·19	106 59·0	19·2	F, sbM
87	J. 519	1 7 4	3·07	89 58·3	19·2	F, pS, R, dif
88	J. 520	1 7 19	3·07	89 56·8	19·2	pF, S, R, vlbM
89	J. 49	1 8 48	3·10	86 27·0	19·1	F, S, iF, N = 13m; 462 f
90	O. St.	1 9 29	3·01	98 43·0	19·1	B, vS, sbMN
91	J. 521	1 11 28	3·09	88 11·1	19·1	F, S, r, N = 14m
92	B. 115	1 12 4	3·33	57 59	19·1	eeF [? different from h 98]
93	Sw. IX.	1 12 7	2·94	107 48·3	19·0	vF, pS, lE, ✱ 8 f 14ˢ, 1′ n
94	B. 116	1 12 17	3·33	58 2	19·0	Neb ✱ 13
95	J. 50	1 12 22	2·97	103 18·5	19·0	F, vS, dif, vlbM
96	Sf. 69	1 12 34	3·31	61 4·0	19·0	pB, pS, vmbMN = 12·13m
97	B. 117	1 12 35	3·18	75 53	19·0	Stellar = 13·5m
98	J. 51	1 13 59	2·97	103 20·6	19·0	vF, vS, iF, bM
99	J. 52	1 15 32	2·97	103 41·1	19·0	vF, S, lbM
100	J. 522	1 15 49	3·03	95 22·5	18·9	F, vS, R, N = 12·5m
101	J. 523	1 16 47	3·14	80 47·6	18·9	vF, pL, E, dif
102	J. 524	1 17 4	3·14	80 50·2	18·9	eF, S, dif
103	J. 53	1 17 21	3·08	88 40·7	18·9	F, vS, R
104	B. 118	1 17 25	3·06	92 11	18·9	Stellar, 13m
105	J. 54	1 17 30	3·08	88 38·8	18·9	F, eS, R, lbM
106	B. 119	1 17 33	3·05	92 19	18·9	vF, S, dif, lbM
107	Sw. X.	1 17 38	3·19	75 51·2	18·9	vF, vS, R, ✱ close p
108	J. 55	1 17 44	2·96	103 21·9	18·9	F, pL, Ens
109	J. 56	1 17 57	3·08	88 39·2	18·9	pB, vS, R
110	B. 120	1 18 3	3·36	57 14	18·9	vF
111	B. 121	1 18 5	3·36	57 15	18·9	✱ 13 with neb
112	J. 525	1 18 39	3·16	79 16·7	18·9	F, S, dif, Epf
113	Burnham	1 18 52	3·23	71 32·2	18·9	vF, 3′ nf of ✱ 5m
114	J. 526	1 19 1	3·14	80 48·6	18·9	eF, vS, R
115	Burnham	1 19 21	3·23	71 30·8	18·8	vF, ✱ 6m 3½′ npp
116	J. 57	1 19 46	3·03	95 42·7	18·8	F, S, R, lbM
117	J. 58	1 20 14	3·05	92 35·5	18·8	pF, S, dif, III. 441 sf
118	J. 527	1 20 32	3·03	95 43·4	18·8	vF, vS, R, lbM
119	J. 59	1 20 47	3·05	92 46·1	18·8	F, Epf, dif, III. 442n
120	J. 60	1 21 5	3·05	92 38·5	18·8	F, S, dif
121	J. 528	1 21 8	3·09	88 11·6	18·8	F, S, R, gbM
122	J. 61	1 21 22	+2·94	105 33·8	−18·8	pB, S, bM

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
123	J. 529	1 21 38	+3·09	88 15·7	−18·8	F, S, R, sbM
124	J. 62	1 22 2	3·05	92 39·6	18·7	vF, vS, dif
125	J. 63	1 22 25	2·95	104 0·1	18·7	vF, vS, R, lbM
126	J. 64	1 22 41	3·05	92 42·5	18·7	eF, stellar, 577 f
127	J. 530	1 22 46	3·01	97 42·5	18·7	F, pS, dif, ✱ 11·5 close
128	J. 65	1 24 30	2·96	103 20·9	18·7	F, R, S, N
129	J. 66	1 24 37	2·96	103 22·7	18·7	F, pL, R, dif
130	J. 67	1 24 38	2·93	106 18·8	18 7	vF, S, dif
131	B. 122	1 25 22	3·35	59 58	18·6	vF, close to ✱ 13·5
132	B. 123	1 25 23	3 35	59 47	18·6	vF, D ✱ (13, 13) close
133	B. 124	1 25 24	3·35	59 50	18·6	vF, S, vlb south, dif
134	B. 125	1 25 33	3·35	59 50	18·6	vF, susp, ✱ 9 n 3′
135	B. 126	1 25 33	3·35	60 18	18·6	vF
136	B. 127	1 25 34	3·35	60 15	18·6	eF, diffic, ✱ 10 np 3′
137	B. 128	1 25 44	3·35	60 13	18·6	vF. pL, dif
138	Sf. 95	1 25 46	3·06	91 23·9	18·6	No description
139	B. 129	1 25 50	3·35	60 15	18·6	vF, v dif, vlbM
140	B. 130	1 25 52	3·35	60 14	18·6	vF, dif
141	J. 68	1 26 0	2·94	105 32·1	18·6	pB, S, R, N 11·5 excentr
142	B. 131	1 26 7	3·36	59 58	18·6	vF, stellar, or ✱ 13 inv
143	B. 132	1 26 18	3·36	59 57	18·6	vF, S, dif, ✱ 13f 0′·6
144	J. 69	1 30 49	2·94	104 1·8	18·4	eF, eS, stellar
145	J. 531	1 31 27	3·07	89 58·2	18·4	F, S, dif
146	J. 70	1 31 54	2·89	108 32·4	18·4	F, vS, R, lbM
147	J. 532	1 33 10	2 92	105 33·8	18·4	F, vS, R, vF ✱ close
148	Sw. X.	1 34 54	3·20	77 3 6	18·3	eeF, pS, v diffic, II. 253 sf
149	J. 533	1 35 36	2·91	107 0·2	18·3	F, pS, Epf, lbM
150	J. 534	1 35 39	3·11	86 31·3	18·3	F, S, R, dif, ✱ 10·5 near, h 148 f
151	Sw. X.	1 36 29	3·20	77 30·2	18·3	eF, pS, np of 2
152	Sw. X.	1 36 39	3·20	77 40·2	18·3	eF, S, R, vF ✱ close, sf of 2
153	Sw. X.	1 37 9	3·19	78 4·6	18·2	eF, pS, R, sp of 2
154	J. 535	1 37 52	3·17	80 3·1	18·2	F, vS, lbM, ✱ 11·5 sp
155	M. Wolf (3214)	1 38 0 ±	4·0	30 55 ±	18·2	vF, eL, dif
156	J. 536	1 38 4	3·17	80 9 0	18·2	pB, S, R, mbMN = ✱ 12
157	Sw. X.	1 38 14	3·19	77 49·8	18·2	eeF, S, R, D ✱ p, nf of 2
158	J. 537	1 38 54	3·00	97 38·6	18 2	vF, vS, R, mbM
159	J. 538	1 39 29	2·98	99 20·0	18 2	pB, S, R, mbM
160	J. 71	1 39 40	2·93	103 57·2	18·2	F, stellar, 13m
161	Sw. X.	1 41 20	3·17	80 20·3	18·1	eeF, vS, R
162	Sw. IX. & X.	1 41 27	3·17	80 10·4	18·1	eeF, S, lE
163	Sf 72, Sw. IX.	1 41 42	3·28	69 59·0	18·1	F, pS, R, bM
164	Sw. IX.	1 42 19	+3 03	94 37 2	−18·1	pF, S, R, bet 2st (? S Cl)

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		h m s	s	° ′	″	
165	Sw. IX.	1 42 19	+3·37	63 4·2	−18·1	eF, S, lE, vF ✱ close f
166	Denning	1 42 48	4·13	28 52	18·0	S Cl, nebulous ?
167	B. 133	1 43 23	3·30	68 49	18·0	eF, ✱ 10·5 n 4′
168	Burnham, J. 539	1 43 31	2·98	99 13 6	18·0	vF, stellar, ✱ 10 f 4′ (707 f 1m)
169	J. 72	1 43 47	2·93	103 22·4	18·0	F, S, Epf, bM, r
170	J. 540	1 45 1	2·98	99 13·3	17·9	F, vS, R, stellar
171	Sw. VIII.	1 47 10	3·50	55 23·7	17 9	pB, pS, cE, ✱ nf
172	J. 541	1 47 43	3·07	89 52 7	17·8	pB, S, R, bM
173	J. 542	1 48 43	3·08	89 24·9	17·8	F, pS, R, lbM
174	J. 73	1 48 59	3·10	86 56·1	17·8	Neb ✱ 13m
175	J. 543	1 49 5	3·08	89 22·2	17·8	vF, dif, diffic
176	J. 74	1 49 48	3·04	92 42·1	17·8	pB, S
177	J. 75	1 49 57	3·06	90 50·1	17·8	F, vS, R, dif
178	Sf. 67	1 50 40	3·53	54 4·4	17 7	pF, N = 13m
179	Sw. X	1 51 33	3·57	52 38·9	17·7	pB, S, lE, ✱ 9·5 nf
180	J. 544	1 52 13	3·34	67 4·7	17·7	vF, eS, R, stellar, sf 776
181	J. 545	1 52 15	3·34	67 1·4	17 6	eF, eS, stellar
182	J. 546	1 52 29	3·15	83 17·3	17·6	F, pL, biN
183	J. 547	1 52 33	3·00	96 1·7	17·6	F, vS, R, lbM
184	O. St.	1 52 53	2·99	97 31·3	17·6	eF, vS
185	J. 548	1 52 59	3·05	92 12·3	17·6	eF, vS, dif
186	J. 549	1 53 18	3 05	92 13·7	17 6	F, double, dist 15″
187	Sw. IX.	1 53 56	3·39	64 12·4	17·6	eeF, R
188	Sw. IX.	1 54 1	3·39	63 39·0	17·6	eeF, vS, R
189	J. 550	1 54 5	3·34	67 7 7	17·6	vF, vS, R, ✱ 13·5 close
190	J. 551	1 54 19	3·35	67 7·9	17·6	F, vS, R, mbM
191	Sw. IX.	1 54 47	3 28	72 18·5	17·5	pB, pL, lE [probably = h 188]
192	Spitaler (2993)	1 54 57	3·25	74 39·3	17·5	F, L, R, lbM
193	Sw. VII.	1 55 14	3·19	79 36·0	17·5	eF, pS, lE, B ✱ sf, F ✱ f
194	J. 552	1 55 50	3·09	88 4·0	17·5	vF, vS, R, ✱ 9·5 f 15s
195	Sw. IX.	1 56 8	3·24	75 58·5	17 5	eeF, S, R, F ✱ s
196	Sw. IX.	1 56 23	3·24	75 57·1	17 5	pF, pS, R, 3st nr
197	J. 553	1 56 51	3·10	87 52·3	17 5	pB, S, E 225°, gbM
198	J. 554	1 58 38	3·17	81 21·6	17·4	pB, pS, R, bM
199	J. 555	1 58 54	3·17	81 25·6	17·3	F, S, R, bM
200	Sf. 71	1 59 18	3·47	59 29·9	17·3	pB, pL, R, bM
201	J. 556	1 59 50	3·17	81 33·8	17·3	vF, S, dif
202	J. 557	2 0 3	3·17	81 30·5	17·3	vF, vS, dif
203	J. 558	2 0 5	3·17	81 33·4	17·3	vF, vS, R, ✱ 10 sf
204	Sf. 98	2 0 17	3·05	92 3·6	17·3	No description
205	J. 76	2 0 22	3·04	92 45·9	17·3	pB, vS, irr R
206	J. 77	2 0 34	+2·98	97 41·7	−17·3	pF, S, irr R

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
207	J. 78	2 0 43	+2·98	97 39·0	−17·3	pF, S, irr R
208	B. 134	2 1 8	3·14	84 18	17·3	vF, pL, dif
209	J. 79	2 2 0	2·98	97 43·6	17·2	pB, S, dif
210	Sf. 101	2 2 32	2·95	100 20·3	17·2	No description
211	J. 559	2 3 53	3·11	86 49·2	17·1	F, pS, R, bM, 851 sf
212	J. 560	2 5 57	3·27	74 3·8	17·0	F, vS, R, stellar
213	J. 561	2 6 24	3·27	74 12·4	17·0	F, S, gbM, ✱ 13·5 close
214	J. 562	2 6 46	3·13	85 29·4	17·0	pB, S, gbM, r
215	J. 80	2 7 12	2·98	97 27·6	17·0	pB, E pf
216	J. 81	2 8 50	3·04	92 39·9	16·9	vF, eS, R, lbM
217	J. 563	2 9 24	2·91	102 34·9	16·9	F, pL, E ns
218	J. 564	2 9 56	3·08	89 22·0	16·9	vF, S, dif, ✱ 13·5 close, 875 sf
219	J. 82, O. St.	2 11 41	3·97	97 33·4	16·8	pB, S, stellar
220	J. 83	2 12 26	2·90	103 25·8	16·7	vF, dif, vlbM
221	Spitaler 1	2 14 33	3·46	62 22·5	16·6	F, pL, R
222	J. 565	2 15 18	3·22	79 0·1	16·6	F, S, irr, N, excentr
223	B. 135, O. St.	2 15 34	2·78	111 23	16·6	vF, S, dif, vF stell N
224	J. 84	2 18 0	2·89	103 12·3	16·5	F, S, irr R, lbM
225	J. 566	2 19 15	3·08	89 27·8	16·4	F, S, R, vlbM, ✱ 14 nf 2′
226	Spitaler 2	2 19 38	3·48	62 25·2	16·4	pF, S, R, bM, 2 F st n
227	Spitaler 3	2 19 56	3·48	62 27·2	16·4	F, p S, R, lbM
228	J. 85	2 20 1	2·86	105 8 4	16·4	vS, R, gbM
229	Thome	2 21 2	2·73	114 27·0	16·3	Neb, 10 mag
230	Burnham	2 22 1	2·92	101 27 9	16·3	eF, S, ✱ 9·4 np 9′
231	J. 567	2 22 42	3·08	89 26·0	16·2	F, vS, R, Stellar
232	Sw. VII.	2 23 53	3·08	89 21·3	16·2	vF, S, R (? = J. 567)
233	J. 568	2 24 24	3·10	87 48·8	16·1	pF, S, R, lbM, vF ✱ s 1′
234	J. 86	2 24 26	3·06	90 45·6	16·1	F, S, dif, r
235	J. 569	2 25 1	3·36	69 58·6	16·1	F, S, dif
236	J. 87	2 25 44	3·06	90 45·0	16·1	F, S, dif, vlbM
237	J. 570	2 26 20	3·08	89 29·2	16·1	F, S, R, ✱ 9·5 p
238	Sw. VII.	2 27 38	+3·25	77 47·0	16·0	vF, vS, R, mbM
239	Roberts	2 27 48	3·72	51 37·9	15·9	vF spiral, F stellar N
240	B. 136	2 30 11	3·78	48 53	15·8	vF, pS
241	B. 137	2 30 41	3·10	88 17	15·8	vF, pS, R, stell N
242	J. 88	2 31 29	2·96	97 32·3	15·8	eF, eS, vF ✱ close
243	J. 89	2 31 37	2·96	97 30·3	15·8	vF, vS, R, bM
244	J. 571	2 32 8	3·10	87 53·8	15·7	vF, vS, dif
245	J. 90	2 32 15	2 85	104 54·4	15·7	pB, S, R, lbM
246	Sw. VII.	2 32 51	3·10	88 7·2	15·7	eeF, vF, R, 2 eF st nr
247	J. 91	2 33 23	2·89	102 19·8	15·7	pB, S, R
248	Burnham	2 33 37	+3·33	72 47·3	−15·7	vF

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		h m s	s	° ′	″	
249	J. 92	2 34 6	+2·96	97 32·4	−15·6	pB, vS, R, dif, 1051 f
250	J. 93	2 34 12	2·86	103 55·1	15·6	vF, pS, iF
251	J. 94	2 34 36	2·84	105 33·6	15·6	F, S, lbM
252	J. 95	2 35 7	2·84	105 26·9	15·6	F, S, bM
253	J. 96	2 35 27	2·84	105 38·9	15·6	bB, iF, bM
254	J. 97	2 35 27	2·84	105 42·5	15·6	vF, eS, R, 1065 close
255	J. 572	2 39 15	3·32	74 19·5	15·4	vF, vS, R, ✳12 f 5ˢ
256	Sw. VIII.	2 40 25	3·99	43 36·4	15·3	eF, lE, S, 1st of 3
257	Sw. VIII.	2 40 30	3·99	43 36·1	15·3	eF, pS, R, v diffic, 2nd of 3
258	Burnham	2 40 49	3·80	49 31·5	15·3	vF, vlbM, ✳9·5 f 2′
259	Burnham	2 41 12	3·80	49 31·4	15·3	vF, double, dist 17″
260	Sw. VIII.	2 41 40	3·99	43 37·3	15·2	eeF, pS, 2 F st nr, 3rd of 3
261	J. 98	2 42 26	2·84	105 3·3	15·2	F, pL
262	Sw. VIII.	2 42 34	3·87	47 45·3	15·1	eeF, pS, R, bet 2st, v diffic
263	J. 99	2 43 25	3·06	90 42·0	15·1	vF, vS, R, N = 14m
264	J. 100	2 43 44	3·06	90 44·4	15·1	vF, eS, R, stellar
265	Sw. VIII.	2 45 46	3·85	48 54·8	15·0	eeF, eS, R
266	Sw. VIII.	2 45 59	3·86	48 18·8	15·0	eF, eS, R
267	B. 138, Sw. VII.	2 46 29	3·27	77 44·0	15·0	vF, pS, dif, II 254 np
268	J. 101	2 48 48	2·84	104 40·4	14·8	vF, vS, irr R, lbM
269	J. 102	2 48 49	2·84	104 38·1	14·8	eF, vS, dif
270	J. 103	2 49 7	2·84	104 46·4	14·8	pB, vS, R
271	J. 573	2 49 18	2·87	102 34·9	14·8	vF, S, R
272	J. 104	2 49 29	2·83	104 45·0	14·8	vF, S, iF
273	J. 574	2 49 55	3·11	87 46·5	14·8	F, pS, lE 235°, bM
274	Sw. VIII.	2 50 50	3·95	46 20·8	14·7	eeF, pS, R, v diffic
275	Sw. VIII.	2 51 40	3·95	46 12·8	14·6	eeF, pS, R, bet 2st
276	J. 575	2 52 8	2·80	106 16·2	14·6	pB, S, mbM
277	J. 576	2 52 35	3·11	87 47·4	14·6	pB, pS, R, N = 12·5
278	Burnham	2 52 39	3·77	52 47·6	14·5	vF, ✳10 p 95″, F✳12″ sp
279	J. 577	2 53 24	3·33	74 20·3	14·5	vF, vS, R, dif
280	Sw. VIII.	2 54 11	3·91	48 11·9	14·4	eF, pS, R
281	Sw. VIII.	2 55 23	3·91	48 11·9	14·4	eeF, vS, ✳ close n, II 607 nr
282	Sw. VIII.	2 56 3	3·90	48 41·7	14·4	eF, S, R, bet 2st nr
283	J. 105	2 56 42	3·06	90 45·7	14·3	pB, eS, R
284	Sw. VIII.	2 56 47	3·92	48 10·9	14·3	eeF, pL, lE, D✳np, bet 2st
285	J. 578	2 57 25	2·87	102 34·3	14·3	F, vS, dif, II. 475 p
286	B. 139	2 57 53	2·96	97 2	14·3	vF
287	J. 579	2 58 17	2·86	102 37·6	14·2	F, vS, R, stellar
288	Sw. VIII.	2 58 17	3·92	48 10·7	14·2	vF, vS, R, 2st nf, ? S Cl
289	Sw. VIII.	2 59 7	4·77	29 12·9	14·2	pB, pL, R, bet 2vFst
290	Sw. VIII.	3 0 35	+3·88	49 33·3	−14·2	eeF, S, R

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		h m s	s	° ′	″	
291	J. 106	3 0 46	+2·85	103 8·1	−14·1	F, S, R, bM
292	Sw. VIII.	3 1 10	3·88	49 46·5	14·1	eF, pS, R, ✶s, bet 2st
293	Sw. VIII.	3 1 44	3·89	49 23·7	14·0	eF, S, R
294	Sw. VIII.	3 1 50	3·88	49 54·2	14·0	vF, pS, irr R
295	Sw. VIII.	3 1 55	3·88	49 55·2	14·0	eF, pS, R
296	Sw. VIII.	3 1 59	3·88	49 54·5	14·0	eF, pS, irrR, F D ✶ p
297	Sw. VIII.	3 4 2	3·93	48 25·5	13·9	eeF, pS, R, v diffic, F ✶ sp
298	J. 580	3 4 5	3·09	89 12·4	13·9	F, pL, 2B points inv
299	J. 107	3 4 25	2·84	103 38·6	13·8	vF, vS, R, lbM
300	Sw. VIII.	3 4 52	3·94	48 4·9	13·8	eF, S, R, ✶ 9 sp, np of 2
301	Sw. VIII.	3 5 27	3·95	48 17·9	13·8	eF, pS, R, sf of 2
302	J. 581	3 5 30	3·14	85 49·4	13·8	pF, pS, R, vSN
303	J. 582	3 5 59	2·86	102 13·3	13·7	eF, eS, stellar
304	Burnham	3 6 6	3·82	52 38·6	13·7	vF, ✶ 76″ sf, np of 2
305	Burnham	3 6 8	3·82	52 39·9	13·7	vF, ✶ 49″ nf
306	J. 583	3 6 18	2·86	102 14·8	13·7	eF, S, R, diffic
307	J. 108	3 6 37	3·06	90 44·1	13·7	pB, vS, r
308	Sw. VIII.	3 6 48	3·92	49 20·6	13·7	eF, pS, iR, r?
309	Sw. VIII.	3 6 52	3·91	49 43·0	13·7	eeF, pS, R, bet 2st
310	Sw. VIII.	3 7 32	3·92	49 11·2	13·6	vF, pS, R, 1259 and 1260 near
311	Sw. VIII.	3 7 34	3·88	50 30·8	13·6	eF, pS, iR, bet 2st, vF ✶ v. close f
312	Sw. VIII.	3 8 54	3·94	48 46·5	13·6	eeF, pS, R, nearly bet 2st
313	Sw. VIII.	3 11 42	3·93	48 36·8	13·5	eeF, vS, R, close D ✶ nr s
314	B. 140	3 11 45	3·03	92 29	13·3	✶ 13 in vF, S neb
315	J. 584	3 11 50	3·13	86 29·4	13·3	vF, S, dif, vlbM
316	Sw. VIII.	3 12 9	3·95	48 34·6	13·3	eeF, pS, R
317	J. 109	3 12 18	2·84	103 15·5	13·3	vF, pL, R
318	J. 110	3 14 11	2·80	105 4·4	13·2	F, S, dif, lbM
319	B. 141	3 14 13	3·94	49 6	13·2	stellar, = 13m
320	Sw. VIII.	3 16 42	3·93	49 42·5	13·0	eF, pS, R, vF ✶ close p
321	J. 111	3 17 58	2·79	105 29·0	13·0	pB, vS, R
322	J. 585	3 18 42	3·13	86 49·1	12·9	vF, pL, vlbM, diffic
323	Sw. VIII.	3 20 11	3·98	48 37·6	12·8	eF, pS, R, p of 2
324	B. 142	3 20 16	2·66	111 51	12·8	F, pS, dif, bM
325	J. 112	3 23 58	2·93	97 31·8	12·5	vF, S, R, vlbM
326	J. 113	3 24 5	2·79	104 54·6	12·5	vF, pL, E ns
327	J. 586	3 24 38	2·79	105 10·7	12·5	eF, vS, dif, v diffic
328	J. 114	3 24 40	2·79	105 7·3	12·5	vF, eS, R
329	J. 115	3 24 51	3·07	90 11·4	12·5	F, vS, R, lbM
330	J. 116	3 24 58	3·07	90 6·8	12·5	F, vS, R, lbM
331	J. 117	3 25 9	3·07	90 11·2	12·5	✶ 13 in neb
332	J. 587	3 25 26	+3·09	89 4·8	−12·4	F, vS, R, sbM

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
333	B. 143	3 27 6	+2·97	95 35	−12·3	eF ✱8·8 nf 4′
334	Denning	3 27 31	7·41	13 48	12·2	pB, S, ✱13 inv sf
335	Sw. VII.	3 29 35	2·33	124 55·0	12·2	pF, pS, eE pf
336	Barnard (3253)	3 30 ±	...	67	...	vF, eeL, v dif
337	Sw. IX.	3 30 12	2·94	97 11·2	12·1	eeF, pL, 3 st nr
338	J. 588	3 30 21	3·12	87 19·6	12·1	vF, S, dif, vF ✱ close
339	O. St.	3 31 47	2·71	108 50·5	12·0	eF, eS, stell N
340	J. 118	3 32 56	2·82	103 34·4	12·0	F, pS, Epf, ✱14 at end
341	Barnard (3253)	3 33 ±	...	68 30 ±	...	vF, eeL, v dif
342	Denning	3 33 20	5·71	22 21	11·8	pB, vS, ✱12 close n
343	O. St.	3 33 48	2·71	108 53·9	11·9	eF, vS, lE90°, dif
344	h. 305 = Sw. IX.	3 34 34	2·98	95 7·0	11·8	eeF, pL, R, II. 455 f
345	O. St.	3 34 50	2·70	108 46·0	11·8	eF, vS, iR, gbM
346	O. St.	3 35 6	2·70	108 49·4	11·8	vF, eS
347	Sw. IX.	3 35 36	2·98	94 45·9	11·7	eF, vS, R, stellar
348	Sf. 70	3 35 47	3·73	58 16·8	11·8	pB, vL, vgbM
349	Barnard (3018)	3 37 55	3·54	66 41	11·6	eF, vS, Pos. 165°, Dist. 36″ from Merope
350	J. 119	3 37 59	2·83	102 14·2	11·6	F, S, R, v dif
351	Barnard (3017)	3 38 33	3·83	55 22·6	11·5	○ = ✱10m, ✱9m p 14ˢ, 2′ s
352	J. 589	3 40 52	2·90	99 10·4	11·3	F, vS, R, bM
353	Barnard (3253)	3 45 ±	...	64 30 ±	...	vF, eeL, v dif
354	Barnard (3253)	3 45 ±	...	67 ±	...	vF, eeL, v dif
355	J. 590	3 45 39	3·46	70 24·8	...	vF, S, R, dif
356	Barnard (3097) Denning	3 53 19	6·14	20 34·4	10·4	pF, pL, bM, ✱8·5 4′ n
357	Sf. 73	3 55 31	3·52	68 14·1	10·3	F, S, R, N = 13·5
358	J. 120	3 55 33	3·48	70 29·0	10·3	vS, dif, lbM
359	Sw. X.	4 4 51	3·68	62 39·8	9·6	eeF, pL, R
360	Barnard (3253)	4 6 ±	...	64 20	...	vF, eeL, v dif
361	Denning	4 7 24	4·96	32 3	9·3	F, L, ? neb Cl
362	J. 121	4 10 9	2·81	102 33·0	8·8	pB, vS, bM
363	Burnham (3048)	4 11 38	3·13	87 18	9·1	eF, ✱9 nf 3′
364	J. 591	4 11 47	3·13	87 9·1	9·0	vF, vS, R, sbM
365	J. 592	4 11 55	3·13	86 59·4	9·0	pB, S, iF, sbM
366	Burnham (3048)	4 12 17	3·11	87 59·2	9·0	eF, 3′ sf of 1550
367	J. 122	4 14 16	2·75	105 7·3	8·9	pB, pL, dif
368	J. 123	4 16 11	2·79	102 56·8	8·7	eS, R, bM
369	J. 124	4 16 55	2·81	102 7·2	8·7	F, S, R, stellar
370	J. 593	4 17 20	2·87	99 43·6	8·6	eF, S, dif
371	B. 145	4 23 3	3·05	90 52	8·2	Stellar, eS, ? neb
372	J. 594	4 23 9	+2·96	95 19·1	−8·1	F, vS, R, lbM

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		h m s	s	° ′	″	
373	J. 595	4 23 48	+2·96	95 10·9	−8·1	F, vS, R, mbM
374	Spitaler 4	4 24 32	3·43	73 40·0	8·0	F, S, R, mbM
375	J. 125	4 24 34	2·78	103 16·7	8·0	vF, dif, lbM
376	J. 126	4 24 42	2·79	102 44·0	8·0	F, iF
377	J. 127	4 24 45	2·79	102 45·4	8·0	F, iF
378	J. 128	4 24 57	2·80	102 36·1	8·0	✱ strongly nebs
379	J. 596	4 25 3	2·91	97 32·5	8·0	vF, S, R, dif
380	J. 129	4 25 12	2·79	103 13·8	8·0	vF, bM
381	Denning	4 26 5	7·80	14 38·7	7·8	F, S, bM, ✱ 12 np
382	J. 597	4 31 14	2·86	99 48·9	7·5	pB, pL, R, SN
383	J. 598	4 31 19	3·28	80 23·4	7·5	vF, S, dif, ✱ 11·5 f
384	J. 599	4 32 32	2·89	98 7·0	7·4	F, eS, R, ✱ 11 n
385	J. 600	4 32 44	2·91	97 22·3	7·4	vF, vS, R, dif
386	J. 601	4 33 18	2·86	99 44·0	7·3	vF, vS, vlbM
387	J. 602	4 34 57	2·91	97 21·5	7·2	eF, pL, v dif, diffic
388	J. 130	4 35 6	2·91	97 34·2	7·2	vF, v dif, S ✱ inv
389	J. 131	4 35 12	2·91	97 34·7	7·2	F, S, R, stellar
390	J. 132 = 603	4 35 16	2·91	97 28·4	7·2	vF, vS, R
391	Denning	4 36 20	8·96	12 4	6·9	F, S, R
392	J. 604	4 39 5	3·14	86 44·8	6·9	pB, S, R, N = 12·5
393	J. 133	4 41 31	2·72	105 46·8	6·6	F, vS, iF, lbM
394	B. 146	4 42 2	2·93	96 32	6·6	vF, dif, ? vS Cl
395	Sw. IX.	4 42 13	3·07	90 0·0	6·6	eF, vS, R, F ✱ close f
396	Denning	4 43 36	6·08	21 53·4	6·4	F, S, R, bMN, FD ✱ sf
397	Spitaler 5	4 51 24	4·16	49 47·0	5·8	F, S
398	O. St.	4 51 27	2·89	98 0 ±	5·8	eF, pL, E 5°, dif
399	Spitaler 35	4 54 48	2·97	94 29·7	5·6	vF, vS, sf of 1741
400	O. St.	4 57 25	2·70	105 58 ±	5·4	eF, eS
401	J. 605	4 57 42	2·84	100 16·6	5·3	vF, vS, R, vSN
402	O. St.	4 59 35	2·86	99 19·6	5·2	eF, pL, iR, dif
403	Spitaler 6	5 5 33	4·15	50 11·6	4·6	eF, eS, R
404	J. 606	5 5 39	3·29	80 24·8	4·6	vF, vS, stellar, ✱ 13 close
405	Schæberle, M. Wolf	5 7 4	3·95	55 50·7	4·5	✱ 6·7 with pB, vL neb
406	Spitaler 7	5 8 6	4·16	50 16·4	4·4	eF neb or eS neb Cl
407	J. 134	5 11 23	2·71	105 40·3	4·2	F, lE ns
408	Sw. VIII.	5 12 10	2·46	115 14·5	4·1	vF, pS, E, ✱ 8·5 south 5′
409	J. 607	5 12 13	3·15	86 49·9	4·1	pB, R, biN ?
410	M. Wolf (3130)	5 13 20	3·93	56 38	3·9	Dif, many st inv
411	Sw. VIII.	5 14 33	2·45	115 28·4	3·9	vF, pS, R, 2 others in field
412	Barnard, J. 608	5 14 36	3·15	86 39·3	3·9	vF, vS, stellar } Pos 115°
413	Barnard, J. 609	5 14 39	3·15	86 39·5	3·9	eF, vS, stellar } Dist 36″
414	Burnham	5 14 40	+3·14	86 49·6	−3·8	eF, ✱ 9 sf 2′

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		h m s	s	° ′	″	
415	J. 135	5 15 2	+2·70	105 41·0	−3·8	vF, vS, R, dif
416	J. 610	5 17 44	2·66	107 23·1	3·6	F, S, gbM
417	M. Wolf (3130)	5 18 50	3·97	55 40	3·5	vL, dif, ∗6 inv
418	Pickering (3049)	5 20 59	2·78	102 48·7	3·3	○ = ∗9·2 (gaseous sp)
419	M. Wolf (3130)	5 22 0	3·83	59 58	3·2	pB, L, mE
420	Pickering	5 25 20	2·97	94 36	2·9	vF, spp ∗9 (not verified)
421	Pickering	5 25 30	2·88	98 11	2·9	vF, L
422	J. 611	5 26 6	2·66	107 19·7	2·9	pB, vS, R, sbM
423	Pickering	5 26 15	3·06	90 43	2·8	vF, L oval ring
424	Pickering	5 26 30	3·06	90 25	2·8	vF, L, brightest f
425	M. Wolf (3130)	5 28	3·91	57 40	2·7	F, vvL
426	Pickering	5 29 40	3·07	90 20	2·6	vF, 5′ diam
427	Pickering	5 29 45	2·92	96 45	2·6	L, probably connected with Great Neb
428	Pickering	5 29 50	2·92	96 36	2·6	
429	J. 612	5 31 32	2·90	97 8·0	2·4	vF, vS, R [? inv in f one]
430	Pickering	5 31 45	2·90	97 10·0	2·4	Neb band 10′ l, np ∗5m
431	Pickering	5 33 10	3·04	91 32	2·3	Neb ∗8·6
432	Pickering	5 33 50	3·04	91 34	2·3	Neb, lE, ∗8·4 inv
433	J. 613	5 34 0	2·79	101 43·9	2·2	F, S, dif, gbM
434	Pickering	5 34 0	3·01	92 29	2 2	Neb, 60′ l, south from ζ Orionis
435	Pickering	5 35 55	3·02	92 23	2·0	Neb, ∗8·5
436	Spitaler 8	5 44 1	4·14	51 24·5	1·3	eF
437	J. 614	5 45 9	2·77	102 36·3	1·2	vF, vS, R, dif
438	Sw. X.	5 46 41	2·64	107 54·3	1·1	eeF, pS, Ens, 2 st p
439	M. Wolf (3130)	5 47 30	3·90	58 0	1·1	eeL, eE 150° ±
440	Denning	5 54 15	10·72	9 55	0·2	vF, S
441	J. 615	5 56 14	2·77	102 30·1	−0·3	eF, vS, diffic, vF ∗ close
442	Denning	6 4 45	14·00	6 57·7	+0·8	F, S, R, mbM
443	M. Wolf (3130) Barnard	6 8	3·62	67 30	0·9	F, narrow, curved
444	M. Wolf (3130) Barnard	6 11 55	3·65	66 41	1·0	Neb, ∗9·5 inv
445	Sw. VIII.	6 22 39	6·36	22 1·4	2·2	eF, S, R, B ∗ sf
446	Barnard	6 23 14	3·32	79 27·4	2·1	Neb ∗10m
447	Barnard	6 23 27	3·31	79 53	2·2	vF, eeL, dif
448	M. Wolf (3027)	6 25	3·24	82 30 ±	2·3	Neby, np ∗ 5 mag
449	Sw. VIII.	6 29 24	7·02	18 31·1	2·8	pF, S, R, bM, bet 2 D st
450	Denning	6 35 4	7·82	15 31	3·3	vF, S
451	Denning	6 35 43	7·83	15 27	3 4	vF, S
452	B. 147	6 42 23	2·67	106 45	3·8	∗13·5 in S neb y
453	B. 148	6 42 54	2·67	106 53	3·8	∗13 in S neb, or 2 or 3 st close
454	Sw. IX.	6 43 22	+3·37	76 56·0	+3·9	eeF, S, e diffic

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		h m s	s	° ′	″	
455	Denning	6 49 9	+20·57	4 12·6	+4·9	vF, eS, sf 2300
456	Sw. X.	6 54 50	2·32	119 58·6	4·8	vF, pS, R, B st nf and np
457	Ld. R., Kobold	6 58 42	4·63	39 38·0	5·2	eF, sp h 430
458	{Ld. R., Sw. VIII., Kobold}	6 59 49	4·63	39 39·7	5·3	F, bM
459	Ld. R., Kobold	6 59 51	4·63	39 36·2	5·3	eF
460	Kobold	6 59 58	4·63	39 34·7	5·3	vF (not seen at Birr)
461	{Ld. R., Sw. VIII., Kobold}	7 0 1	4·63	39 41·9	5·3	vF, 3 F st f
462	Kobold	7 0 11	4·63	39 35·8	5·4	vF (not seen at Birr)
463	{Ld. R., Sw. VIII., Kobold}	7 0 14	4·63	39 39·8	5·4	eF
464	Ld. R., Kobold	7 0 19	4·63	39 38·5	5·4	F
465	Ld. R., Kobold	7 0 47	4·63	39 31·7	5·4	F
466	J. 616	7 1 42	2·98	94 6·2	5·5	* 11·5 in vF neb
467	Denning	7 3 38	10·44	9 49·7	5·8	vF, pS, ssf of 2336
468	B. 149	7 10 52	2·78	102 55	6·2	vF neby, perhaps 2 or 3 st inv
469	Denning	7 12 56	19·76	4 26·7	7·1	F, S, E, sf 2300
470	Sw. X.	7 13 18	4·40	43 39·8	6·4	eF, eS, stellar
471	Sw. IX.	7 32 49	4·53	39 59·5	8·0	eF, pS, R, np of 2
472	Sw. IX.	7 33 4	4·52	40 2·0	8·1	eeF, pS, R, sf of 2
473	Spitaler 9	7 34 46	3·28	80 25·5	8·2	Neb * 14, h 462 nf
474	J. 136	7 37 30	3·69	63 11·2	8·4	pB, vS, dif
475	J. 137	7 38 19	3·80	59 10·2	8·4	vF, vS, dif
476	J. 138	7 38 38	3·70	62 42·5	8·4	vF, vS, lbM, diffic
477	J. 139	7 43 44	3·60	66 9·8	8·9	F, pL, R, dif
478	J. 140	7 45 8	3·68	63 9·2	9·0	vF, vS, dif
479	J. 141	7 45 47	3·69	62 37·0	9·1	pF, vS, R
480	J. 142	7 46 46	3·68	62 51·5	9·1	vF, pL, Ens, dif
481	J. 143	7 50 38	3·61	65 27·8	9·4	vF, vS, dif
482	J. 144	7 51 20	3·64	64 16·7	9·4	vF, S, dif, diffic
483	Spitaler 10	7 51 22	3·65	63 42·0	9·5	F, S, bM, F * nf
484	J. 145, Spitaler 11	7 51 28	3·67	62 57·7	9·5	F, vS, R, bM
485	J. 146, Spitaler 12*a*	7 51 47	3·67	62 55·8	9·5	vF, vS, R, sbM
486	J. 147, Spitaler 12	7 51 48	3·67	63 0·8	9·5	F, S, dif, gbM
487	Sw. VII	7 52 3	3·06	90 17·0	9·6	eeF, vS, R
488	Spitaler 13	7 52 19	3·65	63 42·8	9·6	vF, S, dif, * 13 sp
489	Spitaler 14	7 53 7	3·65	63 34	9·6	vF, vS, sbM
490	J. 148	7 54 49	3·65	63 48·2	9·7	eF, eS, S * f
491	J. 149	7 55 22	3·66	63 5·9	9·7	vF, eS, R
492	{J. 150, Barnard (3038), Spitaler 15}	7 57 9	3·65	63 26·5	9·9	pB, vgbM, Ens, * 13·5 sf
493	J. 151	7 58 59	+3·63	64 30·3	+10·0	pB, Ens

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		h m s	s	° ′	″	
494	B. 150	7 59 7	+3·10	88 34	+10·0	vF, pS, bM
495	J. 617	8 0 43	3·26	80 34·9	10·1	vF, vS, R, gvlbM
496	J. 152	8 1 16	3·64	63 42·9	10·2	pF, S, Epf, lbM
497	J. 153	8 1 41	3·62	64 41·5	10·2	F, S, R, lbM
498	Spitaler (2932)	8 2 6	3·18	84 18·7	10·3	F, pS, R
499	Denning	8 4 54	19·79	3 46·9	10·9	pF, S, mbM, ✱ nf
500	J. 618	8 6 14	2·76	105 38·2	10·5	vF, dif, vF ✱ att
501	J. 154	8 10 25	3·60	65 1·5	10·6	F, R, lbM
502	J. 619	8 14 29	3·25	80 48·2	11·1	F, vS, dif
503	Pechüle (2911)	8 14 51	3·14	86 18·7	11·2	vF, S, lE
504	Sw. VII.	8 15 10	3·16	85 18·1	11·2	vF, pS, R, 4 st f
505	Sw. VII.	8 15 50	3·16	85 10·9	11·2	eF, S, R, lbM
506	Sw. VII.	8 16 5	3·16	85 14·7	11·2	eeF, eS, R, v diffic
507	Sw. VIII.	8 18 28±	3·07	89 59·6	11·4	eeF, pS, vlE, bet 2 st
508	J. 155	8 20 1	3·59	64 25·3	11·6	F, L, R
509	J. 156	8 23 46	3·56	65 31·4	11·8	vF, pL, dif, lbM
510	J. 620	8 25 7	3·04	91 41·2	11·9	F, vS, R, dif
511	Sw. VIII.	8 25 22	6·78	16 1·0	12·1	vF, S, cE, 2 st sf
512	Denning	8 25 32	17·94	3 59·5	12·3	F, S, R, gbM
513	J. 157	8 26 26	2·85	101 52·9	12·1	F, S, dif, r
514	J. 621	8 28 19	3·04	91 34·5	12·2	vF, Ens
515	J. 622	8 28 25	3·04	91 25·5	12·2	vF, vS, dif, 2616 nf
516	J. 623	8 28 45	3·05	91 23·7	12·2	vF, vS, dif, 2616 p
517	J. 624	8 29 18	3·04	91 34·8	12·2	vF, S, iF
518	B. 151	8 29 51	3·09	88 50	12·2	vF ? vS Cl
519	J. 625	8 33 17	3·13	86 53·8	12·5	vF, vS, R, diffic, ✱ 14 close
520	Sw. VIII.	8 38 26	6·62	15 59·5	12·9	pB, pL, bM, ✱ nr
521	J. 626	8 39 28	3·13	86 56·9	12·9	Neb ✱ 13m
522	Sw. IX.	8 43 47	4·65	32 18·4	13·2	pF, pS, R, bM (? 2 eF st inv)
523	J. 627	8 45 38	3·25	80 19·2	13·3	F, S, R, dif
524	J. 628	8 51 49	2·74	108 38·8	13·7	vF, vS, R, vF N ?
525	J. 629	8 54 16	3·05	91 18·1	13·9	F, S, Ens
526	J. 630	8 55 4	3·26	78 36·4	14·0	F, S, R
527	Sw. IX.	9 0 56	3·80	51 49·6	14·3	eeF, pL, R, e diffic
528	J. 631	9 1 35	3·35	73 38·8	14·4	pB, vS, R, N = 13m
529	Denning	9 3 53	6·34	15 41	14·5	pF, pL, E
530	J. 158	9 7 39	3·27	77 33·0	14·8	pB, S, Epf
531	J. 632	9 10 40	3·08	89 40·0	14·9	F, vS, Epf, lbM
532	B. 152	9 12 29	2·82	106 10	15·0	pB, pL, Epf, bM
533	J. 633	9 13 21	3·02	93 24·1	15·1	eF, S, dif
534	J. 634	9 13 59	3·13	86 15·5	15·1	vF, S, dif
535	J. 635	9 15 8	+3·06	90 26·7	+15·2	F, vS, R

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
536	J. 159	9 16 35	+3·49	64 16·5	+15·2	F, S, R, lbM
537	J. 160	9 18 39	2·89	101 47·3	15·3	Neb ✶ 14m
538	B. 154	9 19 18	3·45	66 23	15·4	✶ 13 in vF neb (? = h 599, whose α was uncertain)
539	J. 636	9 22 1	3·04	91 56·8	15·5	pB, S, R, gbM, r
540	J. 637	9 22 43	3·20	81 29·2	15·6	F, S, dif
541	Sw. IX.	9 23 29	3·02	93 38·2	15·6	eeF, pS, R, ✶ 10 s
542	J. 161	9 24 23	2·89	102 34·2	15·7	F, vS, Epf, lbM
543	B. 155	9 24 29	2·86	104 10	15·7	vF, pL, E, dif
544	J. 162	9 27 52	3·46	64 29·2	15·8	vF, dif, diffic
545	J. 163	9 28 3	3·46	64 25·8	15·9	F, Epf, F ✶ f
546	J. 164	9 28 12	2·84	105 46·0	15·9	F, vS, iF, h 3175 f
547	J. 165	9 29 21	2·90	101 49·0	15·9	pB, S, R, lbM
548	J. 638	9 30 50	3·22	79 55·4	16·0	F, vS, lbM, h 614 np
549	J. 639	9 33 24	3·14	85 22·8	16·2	vF, S, iF, bM
550	J. 640	9 33 31	2·98	96 18·8	16·2	F, eS, stellar
551	J. 641	9 33 36	3·18	82 26·3	16·2	F, vS, R, N = 13m
552	J. 166	9 33 44	3·23	78 43·1	16·2	F, vS, stell N = 14m
553	J. 642	9 33 46	3·00	94 48·1	16·2	vF, vS, R, dif
554	Sw. (X.)	9 34 13	3·25	76 55·9	16·2	eeF, eS, alm stell
555	J. 167	9 34 20	3·26	77 4·3	16·2	pB, vS, R, bM
556	J. 168	9 36 9	3·24	78 17·9	16·3	F, vS, R, N = 14m
557	J. 169	9 36 30	3·23	78 22·3	16·3	F, vS, R, vlbM
558	Spitaler (2992)	9 36 47	3·53	59 54·1	16·3	F, R, bM
559	J. 643	9 37 13	3·21	79 44·6	16·3	F, pS, R, dif
560	J. 644	9 38 42	3·07	89 38·7	16·4	F, S, dif, ✶ 10 near
561	J. 645	9 38 43	3·12	86 12·6	16·4	pF, dif
562	J. 646	9 39 1	3·03	93 19·8	16·4	vF, pL, Ens, gbM
563	J. 647	9 39 4	3·12	86 18·6	16·4	pB, S, dif, gbM
564	J. 648	9 39 5	3·12	86 17·0	16·4	pB, pL, Epf
565	J. 649	9 40 10	3·30	73 30·0	16·5	F, S, dif
566	J. 650	9 42 47	3·08	89 35·2	16·6	vF, vS, R, bM
567	B. 156	9 42 57	3·25	76 32	16·6	vF, suspected, 2′ from III. 52
568	J. 651	9 43 30	3·29	73 37·0	16·7	F, pL, Epf, gbM
569	J. 170	9 43 58	3·22	78 25·0	16·7	vF, dif, vlbM
570	J. 652	9 44 13	3·29	73 35·4	16·7	pF, S, R, gbM
571	J. 653	9 44 53	3·29	73 34·2	16·7	pB, S, R, N = 12·5
572	J. 654	9 44 54	3·29	73 31·1	16·7	F, S, R, gbM
573	J. 171	9 46 45	2·92	101 49·6	16·8	eF, vS, R, vS ✶ close
574	J. 655	9 47 28	2·99	96 17·8	16·8	pB, S, R, mbM, ✶ 12s
575	J. 656	9 47 35	2·99	96 12·0	16·8	F, S, R, gbM
576	J. 172	9 47 36	+3·22	78 18·1	+16·8	vF, vS, R

No.	Observer.	R.A. 1890.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
577	J. 173	9 48 34	+3·21	78 50·1	+16·9	F, vS, iF, F✱n
578	J. 174	9 48 46	3·21	78 50·7	16·9	F, vS, R, lbM
579	Sw. VIII.	9 49 48	2·90	103 29·2	17·0	pF, pS, R
580	J. 175	9 50 28	3·21	78 53·7	17·0	pF, vS, iF
581	J. 657	9 50 34	3·28	73 23·0	17·0	pB, S, dif, N = 13 inv
582	J. 658	9 51 18	3·31	71 31·6	17·0	pB, S, iF, gbM
583	J. 659	9 51 23	3·31	71 31·3	17·0	F, vS, gbM
584	J. 176	9 51 37	3·21	78 58·0	17·0	eF, S, R, dif, II. 59 p
585	B. 157	9 52 11	3·24	76 19	17·1	✱13 in eF, S neb
586	J. 660	9 52 51	3·00	96 15·1	17·1	F, vS, mottled
587	J. 661	9 53 0	3·05	91 47·8	17·1	F, pL, R
588	J. 662	9 54 51	3·12	86 16·2	17·2	F, S, R, mottled
589	J. 663	9 57 23	3·01	95 0·3	17·3	vF, vS, biN?
590	J. 664	9 58 38	3·09	88 41·2	17·4	F, dif; neb D✱?
591	J. 177	9 59 58	3·23	77 2·9	17·4	pF, S, R
592	J. 665	10 0 54	3·05	91 49·8	17·5	F, S, R, dif
593	J. 666	10 1 13	3·05	91 51·4	17·5	F, S, R, gbM
594	J. 667	10 1 21	3·07	89 59·7	17·5	F, S, R, gbM, r
595	J. 178	10 2 10	3·21	78 18·6	17·5	F, vS, R, lbM
596	J. 668	10 3 6	3·19	79 16·3	17·5	F, S, dif
597	J. 669	10 3 13	3·00	96 12·6	17·5	F, vS, R
598	Sw. VIII.	10 4 34	3·69	46 4·2	17·6	vF, vS, R, bM, alm stell
599	J. 670	10 6 10	3·02	94 56·5	17·7	pF, S, vlbM
600	J. 671	10 10 6	3·04	92 48·0	17·9	F, pS, R, gbM
601	J. 672	10 10 55	3·15	82 15·9	17·9	vF, vS, dif, sbM
602	J. 673	10 10 59	3·15	82 14·9	17·9	pB, S, Ens
603	J. 674	10 12 22	3·02	94 57·5	17·9	F, vS, R, N = 13·5
604	Sw. IX.	10 14 32	3·99	32 16·0	18·0	eeF, vS, vmE (? seveF st in line)
605	J. 675	10 15 12	3·09	88 5·1	18·0	F, S, R, gbM
606	J. 676	10 16 8	3·20	78 20·3	18·0	vF, vS, R, dif
607	Sw. VIII.	10 16 38	3·25	72 31·1	18·0	eeF, pS, R, v diffic, ✱sp
608	J. 677	10 17 19	3·02	95 20·4	18·1	F, S, R
609	J. 678	10 18 28	3·06	91 30·4	18·1	F, pL, R
610	Sw. VIII.	10 18 36	3·29	69 3·6	18·1	eeF, pS, cE, e diffic
611	Sw. VIII.	10 18 46	3·29	69 2·6	18·1	eF, S, lE
612	J. 679	10 19 40	3·19	78 14·3	18·2	F, vS, dif, vlbM
613	J. 680	10 19 43	3·19	78 17·0	18·2	F, vS, R
614	J. 681	10 19 46	3·05	92 45·1	18·2	vF, dif
615	J. 682	10 19 57	3·19	78 12·8	18·2	vF, S, R
616	J. 683	10 25 16	3·23	73 27·1	18·4	F, pS, R
617	J. 179	10 25 51	2·96	101 55·9	18·4	vF, vS, R, bM
618	J. 180	10 25 51	+2·96	102 0·6	+18·4	F, S, Epf, lbM

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
619	Sw. VIII.	10 26 4	+3·20	76 44·1	+18·4	eeF, S, R, 3 Fstf
620	J. 181	10 26 8	3·19	77 24·8	18·4	vF, vS
621	J. 684	10 26 9	3·10	86 37·5	18·5	F, S, R
622	Sw. IX.	10 27 10	3·18	78 4·7	18·5	vF, pS, E, ✱ 9s
623	J. 685	10 28 4	3·11	85 43·4	18·5	F, S, R
624	J. 686	10 29 14	3·00	97 37·0	18·5	F, vS, R
625	O. St.	10 29 50	2·85	113 11·8	18·6	eF, pL, E 110°, dif
626	J. 687	10 29 56	3·02	96 18·1	18·6	F, S, R, r
627	J. 688	10 30 13	3·05	92 38·3	18·6	F, S, r
628	J. 182	10 30 18	3·13	83 40·7	18·6	vF, vS, iF
629	B. 158	10 30 28	2·82	116 50	18·6	vF, vS st inv, Cl ?
630	J. 689	10 31 32	3·02	96 26·8	18·7	F, eS, stellar, ✱ 9·5 sp 1½′
631	J. 690	10 31 58	3·02	96 19·7	18·7	vF, vS, dif
632	J. 691	10 32 2	3·07	89 41·2	18·7	F, S, R, gbM
633	J. 692	10 32 14	3·07	89 39·8	18·7	vF, vS, R, SN
634	J. 693	10 33 37	3·13	83 16·7	18·7	vF, S, r
635	J. 694	10 34 17	3·21	73 38·2	18·7	F, S, R, gbM
636	J. 695	10 34 35	3 12	84 56·5	18 7	vF, vS, r
637	J. 696	10 34 52	3·21	73 54·7	18 7	F, vS, in line w 3 st
638	J. 697	10 36 18	3·22	73 22·8	18·8	F, vS, R
639	Sw. VII.	10 38 18	3 22	72 20·5	18·8	eF, S, mEns, ✱ 10 nf 5′
640	B. 159	10 38 56	3·40	54 31	18·9	vF, pS, E, D ?
641	B. 160	10 39 57	3·40	54 36	18·9	vF, pS, dif
642	Sw. VII.	10 40 28	3·22	71 4·5	18 9	vF, pS, lE, 2 st f
643	J. 183	10 42 6	3·17	77 3·4	18·9	pF, S, Ens, lbM
644	Sw. IX.	10 43 4	3·72	33 51·1	19·0	eeF, pS, lE, B ✱ sf, sp of 2
645	J. 698	10 43 5	3·03	95 18·4	19·0	F, S, R
646	Sw. IX.	10 43 11	3·72	33 47·2	19·0	eeF, pS, R, nf of 2
647	J. 184	10 43 37	2·98	102 7·1	19·0	eF, vS, dif, III. 522 p
648	J. 185	10 43 38	3·18	76 57·9	19·0	eF, vS, vF ✱ inv, diffic
649	J. 699	10 43 40	3·09	88 5·6	19·0	F, S, lbM, ✱ 10·5 sp
650	J. 186	10 43 44	2 97	102 42·1	19 0	pF, vS, R
651	J. 700	10 43 59	3·06	91 24·5	19·0	pB, pS, gbM, r
652	J. 187	10 44 4	2·98	101 53·8	19·0	F, vS, R, bM
653	J. 701	10 44 56	3·07	89 49·7	19·0	F, S, R, dif
654	J. 188	10 46 52	2·99	100 59·0	19·1	vF, S, diffic
655	J. 189	10 47 12	3·08	89 36·8	19·1	eF, iF
656	B. 161	10 47 40	3·21	71 39	19·1	vS, Cl, neb ?
657	J. 702	10 50 47	3·04	94 9·4	19·2	F, pS, lEns
658	J. 703	10 50 57	3·14	80 58·9	19·2	F, vS, R, stellar
659	J. 704	10 50 59	3·03	95 30·8	19·2	F, S, R, bM
660	J. 705	10 51 15	+3·09	87 51·1	+19·2	vF, S, r

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
661	J. 706	10 51 40	+3·09	87 36·1	+19·2	eF, vS, R, diffic
662	J. 707	10 52 9	3·09	87 39·2	19·2	vF, SN, diffic
663	Sw. X., J. 190	10 53 16	3·15	78 49·1	19·2	eF, vS, R, 2st s, 1st of 4
664	Sw. X., J. 191	10 53 26	3·15	78 42·2	19·2	eF, vS, R, lbM, 3492 f
665	J. 708	10 53 32	2·97	103 6·9	19·2	F, vS, R, bM
666	Sw. (X.), J. 192	10 53 54	3·15	78 46·4	19·3	eF, vS, iF, 4th of 4
667	J. 709	10 59 16	3·17	74 9·5	19·4	vF, vS, R, vlbM
668	J. 710	10 59 18	3·17	74 12·4	19·4	vF, vS, R, bM
669	J. 711	11 0 2	3·12	82 56·5	19·4	pB, vS, R, sbM
670	Spitaler 16	11 0 13	3·12	82 31·8	19·4	F, pS, R, bM
671	J. 712	11 0 18	3·08	88 28·3	19·4	vF, pS, R
672	J. 193	11 1 1	3·00	101 43·5	19·4	vF, vS
673	J. 194	11 2 17	3·08	89 19·2	19·4	vF, vS, Epf, r
674	Spitaler 36	11 3 12	3·38	45 37·0	19·5	pF, R, bM, D ✱ sf
675	J. 713	11 3 29	3·10	85 33·8	19·5	pB, pL, Ens, biN?
676	Sw. X.	11 5 26	3·13	80 10·5	19·5	vF, pS, lE, bet 2 dist st
677	J. 195	11 6 36	3·14	76 56·5	19·5	F, pL, gbM
678	J. 714	11 6 51	3·11	82 39·5	19·5	F, S, r, N = 13·5
679	J. 715	11 9 34	3·00	103 12·7	19·6	F, S, R, sbM
680	J. 716	11 10 44	3·07	91 10·9	19·6	F, S, R, gbM
681	J. 196	11 11 31	3·01	101 22·9	19·6	vF, S, iF, diffic
682	Sw. VIII.	11 13 50	3·17	69 0·9	19·7	eF, eS, R, vF ✱ close np
683	B. 162	11 14 19	3·09	86 28	19·7	Neb object 13·5 mag
684	B. 163	11 14 22	3·09	86 24	19·7	F, S, ✱ ✱ sp 0′·5
685	Sw. VII.	11 14 40	3·16	71 25·7	19·7	eeF, pS, R, ✱ nf
686	J. 717	11 15 51	3·10	83 35·2	19·7	eF, vS, R, v diffic
687	Sw. IX.	11 16 35	3·35	41 23·1	19·7	eF, eS, R, stell N, F ✱ f
688	O. St.	11 16 36	3·03	99 1·6	19·7	eF, vS, R
689	O. St.	11 16 36	3·02	103 3·7	19·7	eF, vS, R, dif
690	J. 718	11 17 15	3·04	97 34·8	19·7	pB, S, R, N = 12 m
691	Sw. VII.	11 18 31	3·47	30 4·4	19·8	pF, pS, R, 2 st nr
692	Spitaler 37	11 18 38	3·11	79 16	19·8	F, vS, R, ✱ 12 sf 2′
693	J. 719	11 19 41	3·06	94 13·9	19·8	F, pS, R, gbM, r
694	Ld. R. Sw. (X)	11 20 44	3·44	30 40	19·8	vS, forms D neb with I 247
695	J. 197	11 20 53	3·03	100 56·8	19·8	eF, S, v diffic
696	Spitaler 38	11 21 25	3·11	80 7·9	19·8	vF, pS, R, vlbM
697	J. 720	11 21 27	3·07	90 51·8	19·8	F, S, R, gbM
698	Spitaler 39	11 21 49	3·11	80 7·1	19·8	F, vS, R, bM
699	Spitaler 40	11 21 52	3·11	80 14·5	19·8	F, vS, lE, ns
700	J. 198	11 21 55	3·16	68 38·7	19·8	pS, R, lbM
701	Sw. VIII.	11 23 35	3·15	68 45·8	19·8	eF, vS, R, 2 pB st sf
702	J. 721	11 23 47	+3·06	94 9·3	+19·8	F, vS, R, N = 13·5

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
703	Sw. VIII.	11 24 44	+3·03	100 49·5	+19·8	eeF, S, R, p of 2
704	Sw. VIII.	11 24 49	3·03	100 46·5	19·8	eF, vS (? close D), f of 2
705	Sw. IX.	11 25 16	3·31	38 58·6	19·8	eeF, vS, R
706	J. 199	11 26 9	3·03	102 34·3	19·8	eF, vS, lbM
707	Kobold (3241)	11 26 25	3·14	67 50·8	19·9	pF, pS, bM
708	Sw. IX.	11 26 26	3·29	40 9·0	19·9	eF, S, R, 1st of 4
709	Sw. IX.	11 26 41	3·29	40 9·5	19·9	eeF, S, R, 2nd of 4
710	J. 722	11 27 7	3·16	63 21·7	19·9	F, vS, R, lbM
711	Sw. IX.	11 27 16	3·29	40 15·5	19·9	eeF, pS, R, F ✱ close sp
712	Sw. IX.	11 27 21	3·29	40 8·0	19·9	eF, S, R, pB ✱ nf
713	B. 164	11 27 28	3·13	72 23	19·9	eF, susp, 3′ nnf from ✱ 6
714	O. St.	11 29 24	3·04	99 4·5	19·9	vF, pS, lE 170°, gbMN
715	J. 723	11 29 48	3·05	97 36·0	19·9	F, pS, R
716	J. 200	11 31 53	3·07	89 25·9	19·9	vF, S, lbM
717	O. St.	11 32 15	3·04	99 52 ±	19·9	eF, pS, Epf, dif
718	Spitaler 41	11 32 40	3·10	80 21·1	20·0	vF, S
719	Spitaler 42	11 33 5	3·10	80 12·7	20·0	F, pL, lE 45°, bM
720	Spitaler 43	11 35 10	3·10	80 27·0	20·0	F, S, R
721	J. 724	11 35 21	3·05	97 33·4	20·0	pF, pL, Epf
722	Spitaler 44	11 35 24	3·10	80 9·6	20·0	eF, vS, ✱ 10 nf 2′
723	J. 725	11 35 50	3·05	97 32·9	20·0	pB, S, N = 12·5, r
724	Spitaler 45	11 36 14	3·10	80 11·2	20·0	F, lE 45°, S, bM
725	J. 726	11 36 20	3·07	90 53·6	20·0	F, vS, lE ns, ✱ 11 n 1′
726	Spitaler 17	11 36 25	3·16	55 55·2	20·0	vF, pL, R
727	J. 201	11 37 15	3·10	78 26·3	20·0	vF, eS, R, 3839 p
728	J. 727	11 37 42	3·07	90 49·6	20·0	vF, S, R
729	Spitaler 18	11 37 59	3·16	55 54·5	20·0	F, pS, R
730	J. 728	11 38 24	3·08	85 59·5	20·0	F, vS, R, gbM, r
731	Sw. IX.	11 38 33	3·22	39 39·5	20·0	vF, vS, R
732	B. 165	11 38 44	3·12	68 47	20·0	vF, v dif
733	J. 729	11 38 51	3·06	97 22·9	20·0	F, vS, R, gbM, r
734	J. 730	11 38 55	3·06	97 29·8	20·0	F, S, dif
735	J. 202	11 40 59	3·09	79 0·6	20·0	eF, S, iF
736	J. 203	11 41 6	3·10	76 30·4	20·0	vF, eS, R
737	J. 204	11 41 14	3·10	76 29·8	20·0	vF, eS, R, N = 14
738	J. 731	11 41 45	3·07	93 54·0	20·0	F, S, R, N = 14 m
739	J. 732	11 43 7	3·11	65 23·9	20·0	vF, S, R, ✱ 10·5 f
740	Sw. IX.	11 43 19	3·20	33 52·0	20·0	eeF, pL, iR, II. 787 s
741	J. 733	11 43 23	3·07	94 3·4	20·0	pB, S, R, sbMN = 12m
742	Sw. VIII.	11 43 42	3·11	68 25·1	20·0	eeF, pS, R, pB ✱ sp
743	J. 205	11 46 16	3·06	102 28·8	20·0	F, S, dif
744	J. 734	11 46 51	+3·10	66 1·6	+20·0	eF, vS, v diffic

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
745	J. 206	11 46 59	+3·07	89 5·5	+20·0	F, vS, stellar, N = 14
746	J. 735	11 48 22	3·10	63 19·9	20·0	F, pS, R
747	J. 736	11 49 55	3·06	97 31·0	20·0	F, vS, R, stellar
748	J. 737	11 50 15	3·08	81 45·6	20·0	F, vS, R, sbMN = 13
749	Spitaler 46	11 51 20	3·11	46 29·2	20·0	pB, L, R, lbM
750	Spitaler 47	11 51 38	3·11	46 29·8	20·0	pB, L, lE 35°, bM
751	Spitaler 48	11 51 39	3·11	46 39·0	20·0	pF, pL, lE 45°, mbM
752	Spitaler 49	11 52 2	3·11	46 39·2	20·1	vF, S, iR, ✱ 13 nf 1½′
753	J. 738	11 52 3	3·07	89 44·8	20·1	pB, vS, R, vmbM, ✱ 11 nf
754	J. 739	11 52 14	3·07	90 52·7	20·1	F, S, R, sbM
755	Sw. VIII.	11 53 58	3·08	75 5·7	20·1	eeF, S, E, bet 2 st
756	J. 740	11 55 47	3·07	84 21·9	20·1	vF, pL
757	B. 166	11 56 17	3·07	36 34	20·1	Susp., close to ✱ 12
758	Sw. VII.	11 56 53	3·08	26 43·7	20·1	eeF, pS, R, bet 2 distant st
759	B. 167	11 58 0	3·07	68 58	20·1	pB, pL, Epf
760	O. St.	11 58 42	3·07	118 30·8	20·1	eF, vS, rr, bMN
761	J. 207	11 58 44	3·07	101 53·9	20·1	Neb ✱ 14m
762	J. 741	12 1 4	3·06	63 28·2	20·1	pB, S, R, N = 12m
763	J. 742	12 1 8	3·06	63 25·0	20·1	F, vS, N = 13m
764	O. St.	12 3 1	3·09	118 57·6	20·1	eF, pL, Ens, lbN
765	B. 168	12 3 23	3·06	73 5	20·1	vF, susp 6′ n of II. 83
766	J. 208	12 3 41	3·08	101 53·0	20·1	pB, E ns, sbMN = 14m
767	J. 209	12 3 54	3·07	77 7·0	20·1	F, vS, stell, N = 14m
768	J. 210	12 4 38	3·06	77 4·6	20·1	vF, pS, R, gbM
769	J. 211, Spit. 19	12 5 24	3·06	77 6·0	20·1	vF, pS, vlbM
770	J. 743	12 5 52	3·07	93 46·7	20·1	vF, vS, R, ✱ 13·5 n 1′
771	Spitaler (3167)	12 8 4	3·06	76 2	20·0	vF, S, R, ✱ 3′ south
772	B. 170	12 8 11	3·05	65 14	20·0	vF, vS, stell
773	J. 744	12 10 59	3·06	83 5·3	20·0	F, vS, dif, 2 vF st inv
774	J. 745	12 11 39	3·08	95 59·1	20·0	F, vS, R, gbM
775	B. 171	12 11 45	3·06	76 20	20·0	vF, S, stell N
776	J. 746	12 11 52	3·06	80 23·5	20·0	F, pL, R
777	Sf. 18	12 12 30	3·03	60 55·4	20·0	vF
778	Sw. VII.	12 12 32	2·94	33 13·3	20·0	eF, pS, R, bet 2 st
779	Sf. 19	12 12 46	3·03	59 20·1	20·0	F
780	J. 747	12 12 54	3·03	63 27·7	20·0	pB, S, R, N = 12·5 m
781	B. 172	12 12 56	3·05	74 15	20·0	vF, S, dif
782	J. 212	12 14 24	3·06	83 27·4	20·0	eF, S, R
783	Sw. VII.	12 14 34	3·04	73 29·5	20·0	eF, S, R
784	Sw. VIII.	12 15 23	3·08	93 47·1	20·0	vF, pL, mE, pB ✱ s
785	J. 213	12 15 49	3·09	102 27·0	20·0	F, vS, R, stell
786	J. 214	12 15 58	+3·09	102 25·9	+20·0	vF, eS, R, stell

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
787	Sw. VII.	12 18 24	+3·04	73 6·0	+20·0	eF, pS, R, B ✱ n, II. 88f
788	J. 748	12 19 2	3·04	73 1·6	20·0	pB, pL, R, II. 88 south
789	J. 749	12 19 14	3·06	81 45·0	20·0	F, vS, R, N = 14m, vF ✱ close
790	B. 173	12 19 29	3·05	80 12	20·0	vF, vS, f h 1256
791	Sf. 26	12 19 59	3·02	66 35·5	20·0	BN = 12m
792	J. 750	12 20 5	3·03	72 53·7	20·0	F, S, gbM
793	Sw. VIII.	12 20 54	3·05	79 47·7	20·0	eF, S, mE, 3 others in field
794	J. 215	12 21 3	3·04	77 8·0	20·0	F, S, Epf, bM
795	J. 751	12 21 31	3·02	65 54·9	20·0	pB, S, stellar, 13m
796	J. 216	12 22 23	3·03	72 48·8	20·0	F, S, Ens, r
797	J. 217	12 24 49	3·03	74 5·9	19·9	F, S, R, gbM
798	J. 218	12 25 29	3·03	73 48·0	19·9	vF, eS, R
799	Sw. VIII.	12 26 42	3·09	96 35·4	19 9	eF, eS, R, ? eF ✱ att p
800	J. 219	12 26 52	3·03	73 51·7	19·9	F, S, R, gbM
801	Sw. IX.	12 27 8	2·85	36 57·6	19·9	eeF, S, R, ✱ close n
802	B. 174	12 30 28	2·38	14 56	19·9	vF, S, stellar
803	J. 220	12 32 35	3·02	72 39·2	19·8	eF, S, v diffic
804	Sw. VII.	12 33 57	3 09	94 15·7	19·8	vF, vS, R
805	Sw. VIII.	12 34 14	3·02	75 29·6	19·8	vF, pL, R, 2st n & nf
806	J. 221	12 34 50	3·13	106 35·0	19 8	eF, eS, R, ✱ 12 close
807	J. 222	12 34 54	3·13	106 38·3	18·8	pF, vS, R, gbM
808	B. 175	12 34 58	3·00	69 17	19·8	S nebs Cl
809	Sw. VII.	12 35 2	3·03	77 29·4	19·8	eF, pS, R, M 59 s
810	Sw. VII.	12 35 4	3·02	76 38·1	19 8	eF, pS, mE
811	B. 176	12 37 31	3·11	99 26	19·8	Nebs ✱ 13m, sf II. 558
812	J. 752	12 37 39	3·09	93 39·9	19·8	pB, S, R, N = 13m
813	Spitaler 20	12 38 17	2·97	66 11·9	19·8	F, pS, iR, bM
814	J. 753	12 38 19	3·10	97 19·7	19 8	pB, vS, R, r
815	J. 223	12 39 21	3·02	77 21·5	19·7	F, vS, ✱ 14 inv
816	Sw. VII.	12 39 39	3·03	79 22·9	19·7	eeF, vS, R, D ✱ nf, np of 2
817	Sw. VII.	12 39 54	3·03	79 22·4	19·7	eeF, vS, R, sf of 2
818	Spitaler 50	12 39 55	2·93	59 29·8	19·7	vS, R, bM, ✱ 12 nf 2½′
819	Spitaler 51	12 40 21	2·93	58 30·0	19·7	} D neb, conn, vF, vS, sf one brighter
820	Spitaler 52	12 40 22	2·93	58 30·8	19·7	
821	Spitaler 53	12 40 37	2·93	59 26·8	19·7	R, pL, glbM, 2 st ssf
822	Spitaler 54	12 40 56	2·93	59 10	19·7	F, eS, bM
823	B. 177	12 40 58	2·94	62 2	19·7	Susp, 2's of II. 381
824	J. 754	12 42 29	3·09	93 48·6	19·7	pB, pL, Epf, biN
825	Sw. VII.	12 43 2	3·09	94 36·9	19·7	eeF, pS, R, nearly bet 2st
826	Spitaler 55	12 44 33	2·92	58 10·8	19·7	F, pS, R, gbM
827	J. 224	12 44 53	2·99	72 57·9	19·7	vF, S, Epf, dif
828	J. 755	12 45 0	+3·11	97 22·0	+19·7	F, vS, R, N = 13·5 m

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
829	B. 178	12 45 7	+3·14	104 46	19·6	Neb ✻ 13m
830	Sw. IX.	12 45 9	2·70	35 33·4	19·6	vF, vS, lE, stellar
831	Spitaler 56	12 45 52	2·93	62 46·5	19 6	F, S, R, bM
832	Sf. 22, Spitaler 57	12 47 10	2·93	62 49·5	19·6	F, S, R, bM, D ✻ nf
833	Sw. VIII.	12 49 27	3·10	95 58·1	19·6	vF, S, R
834	Spitaler 58	12 49 28	2·93	62 54·5	19·6	pF, pS, sbM
835	Spitaler 59	12 50 3	2·92	62 46·5	19·6	F, S, R
836	Sw. VII.	12 50 21	2·46	25 37·4	19·6	eeF, vS, v diffic, bet 2st
837	Spitaler 60	12 50 42	2·92	62 45	19·5	F, S, R
838	Spitaler	12 51 28	2·92	62 51	19·5	vF, 1½′nf 4849
839	B. 179	12 51 31	2·91	61 6	19·5	stellar, 13m
840	J. 756	12 51 41	3·01	78 36·5	19·5	F, S, R, lbM, r
841	H. C. Wilson	12 52 26 ±	2·94	67 24	19·5	vF (Astr & Astrophys, No. 103)
842	Sf. 2	12 53 54	2·89	60 12·0	19·5	pF
843	Sf. 3	12 54 54	2·89	60 12·7	19·5	F, bMN
844	O. St.	12 55 40	3·26	119 46·1	19·4	vF, vS, lbM
845	Sw. VIII.	12 58 20	2·99	77 8?	19·4	eeF, S, R, F ✻ nr p
846	J. 225	12 58 33	2·92	66 9·2	19·4	vF, R, lbM, diffic
847	Sw. IX.	12 59 57	2·59	35 34·0	19·4	vF, S, R, bet 2st
848	J. 226	13 0 7	2·97	73 15·0	19·3	eF, vS, diffic
849	J. 757	13 0 27	3·07	90 10·6	19·3	F, pL, R, gbM
850	J. 758	13 0 39	3·07	90 6·3	19·3	vF, S, R
851	H. C. Wilson	13 1 46	2·93	68 12·1	19·3	vF (Astr & Astrophys, No. 103)
852	Sw. VII.	13 2 12	2·45	29 5·6	19·3	vF, pS, R, B ✻ p
853	Sw. IX.	13 2 48	2·58	36 29·6	19·3	eeF, pS, R
854	J. 227	13 3 4	2·90	64 40·5	19·3	pF, vS, R, vlbM
855	J. 759	13 3 23	3·10	93 44·3	19·3	F, S, ✻ 13·5 sp
856	J. 228	13 3 53	2·93	68 42·9	19·3	F, E, lbM
857	J. 229	13 6 58	2·95	72 10·7	19·2	pF, vS, R, gvlbM
858	J. 230	13 8 0	2·94	72 1 9	19·1	F, vS, R, stellar, N = 12m
859	J. 231	13 8 5	2·94	72 2·0	19·1	pF, R, N = 14m
860	J. 232	13 8 20	2·88	64 38·9	19·1	F, vS, R, N = 14m
861	Spitaler 21	13 8 37	2·80	54 55·8	19·1	F, vS, R, sbM
862	J. 233	13 9 26	2·92	69 12·6	19·1	pB, eS, R, N = 12m
863	J. 234	13 9 44	3·19	106 30 9	19·1	F, S, iF, biN
864	J. 235	13 10 20	2·91	68 34·2	19·1	vF, pS, R, bMSN
865	J. 760	13 10 20	3·11	95 5·3	19·1	F, vS, R, stellar
866	Sw. VIII., J. 236	13 10 28	2·91	68 34·4	19·1	vF, S, R, lbM
867	Sw. VIII., J. 237	13 10 31	2·91	68 37·3	19·1	vF, R, lbM
868	Sw. VIII., J. 238	13 10 39	2·91	68 39·0	19·1	vF, R, lbM
869	Sw. VIII., J. 239	13 10 42	2·91	68 34·9	19·1	vF, S, R, lbM
870	Sw. VIII., J. 240	13 10 43	+2·91	68 39·7	+19·1	vF, S, R, lbM

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	′	
871	J. 761	13 10 55	+3·03	84 51·8	+19·1	pB, pS, Epf, dif
872	Sw. X.	13 11 9	3·02	82 54·3	19·1	eeF, pS, R, lbM
873	J. 762	13 11 13	3·03	84 48·1	19·1	F, vS, R, bMN=13·5m
874	O. St.	13 11 20	3·28	116 53·5	19·1	vF, S, R, dif
875	Sw. IX.	13 11 30	2·41	31 43·0	19·1	eF, vS, R, stellar
876	J. 763	13 11 32	3·03	84 46·9	19·1	F, pL, dif
877	Sw. X.	13 11 54	3·02	83 10·8	19·1	eeF, pS, pB ∗ f 13ˢ
878	Sw. X.	13 11 57	3·02	83 8·5	19·1	eeF, pL, v diffic
879	O. St.	13 11 59	3·28	116 41·5	19·0	eF, pL, iR, dif
880	Sw. X.	13 12 4	3·02	83 9·0	19·0	eeF, pS, Ens, pB ∗ s, 5th of 5
881	J. 241	13 13 2	2·94	73 24·6	19·0	F, vS, R, stellar
882	J. 242	13 13 13	2·94	73 21·7	19·0	pF, vS, R, stellar
883	Spitaler 22	13 14 7	2·77	55 7·4	19·0	F, pS, iR, bM
884	Sw. VI.	13 15 31	3·16	101 59·7	18·9	vF, pS, R
885	Sw. VIII.	13 15 48	2·89	67 56·1	18·9	vF, pS, R
886	J. 764	13 16 42	3·10	93 39·6	18·9	vF, vS, bMN, v diffic
887	Sw. VI.	13 16 48	3·16	101 43·7	18·9	vF, vS, nearly bet 2st
888	Sw. VIII.	13 18 57	2·95	75 31·5	18·9	eeF, pS, R
889	J. 243	13 19 42	2·96	77 23·7	18·8	F, vS, R, N=14m
890	J. 765	13 20 56	3·20	105 21·8	18·8	vF, sbM ∗ 13·5, r
891	J. 766	13 22 52	3·06	88 59·1	18·7	F, S, R, N=13m
892	J. 767	13 24 33	3·09	92 0·3	18·7	pB, iF, bM, r
893	J. 768	13 24 34	3·09	91 54·2	18·7	F, vS, dif
894	J. 244	13 25 17	2·92	72 13·4	18·7	pF, vS, R, lbM
895	Sw. VIII.	13 25 59	2·71	53 37·2	18·6	vF, pL, R, sbM, D ?
896	J. 245	13 27 8	3·02	84 25·5	18·6	vF, vS, dif, lbM
897	B. 180	13 27 12	2·90	71 35	18·6	vF, s of h 1634
898	J. 246	13 27 17	2·94	76 0·8	18·6	vF, vS, dif
899	J. 769	13 27 39	3·14	97 22·3	18·6	F, vS, R, sbM N
900	J. 247	13 27 45	2·98	79 56·5	18·6	F, S, R, gbM
901	J. 248	13 28 49	2·94	75 58·0	18·5	pF, eS, R
902	Sw. VII.	13 30 17	2·45	39 20·1	18·5	eeF, S, mE, v diffic
903	J. 770	13 31 17	3·07	89 30·7	18·5	pB, lEns, gbM N=13m
904	J. 771	13 31 24	3·06	88 45·2	18·4	F, vS, dif
905	J. 249	13 33 26	2·83	66 8·6	18·4	F, vS, R, lbM, stellar
906	J. 250	13 33 34	2·83	65 56·9	18·4	eF, S, bM
907	Sw. VII.	13 33 53	2·40	38 34·1	18·4	eF, pS, R
908	J. 772	13 34 4	3·11	93 38·4	18·3	eF, pS, ∗ 13·5 close
909	Sf. 28	13 34 13	2·82	64 47·1	18·3	No descr
910	J. 251	13 34 32	2·83	66 0·2	18·3	F, S, bM, r
911	J. 252	13 34 49	2·83	66 2·6	18·3	eF, eS, R, lbM
912	J. 253	13 34 53	+2·83	66 2·6	+18·3	eF, eS, R, lbM

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
913	J. 254	13 34 54	+2·83	66 7·2	+18·3	vF, vS, R, dif
914	J. 255	13 35 4	2·83	66 5·8	18·3	vF, vS, R, dif
915	J. 256	13 35 55	3·23	106 37·4	18·3	eF, vS, diffic
916	Sf. 27	13 36 0	2·82	64 49·0	18·3	N = 13m
917	Barnard (2998)	13 37 32	2·24	33 39·5	18·2	S
918	Barnard (2998)	13 37 35	2·24	33 42·0	18·2	vF, vS
919	Barnard (2998)	13 37 38	2·24	33 42·5	18·2	cB, R, bM
920	J. 773	13 37 57	3·19	101 52·2	18·2	F, vS, R, bM N, r
921	Barnard (2998)	13 37 58	2·24	33 37·6	18·2	vS, R, bM
922	Barnard (2998)	13 38 1	2·24	33 41·0	18·2	vS, R, bM
923	Barnard (2998)	13 38 5	2·24	33 40·5	18·2	vS
924	Burnham (2930)	13 38 9	3·19	101 45·1	18·2	F, S, dif, 86 Virg nf
925	Barnard (2998)	13 38 10	2·24	33 41·5	18·2	vS
926	Barnard (2998)	13 38 19	2·24	33 39·0	18·2	vS, R, bM
927	Burnham (2930)	13 38 24	3·19	101 45·7	18·2	F, S, dif, 86 Virg nf
928	Barnard (2998)	13 38 30	2·23	33 40·5	18·2	F, vS, R, gbM
929	Barnard (2998)	13 38 31	2·23	33 38·5	18·2	vS, R, bM
930	Barnard (2998)	13 38 35	2·23	33 37·0	18·2	F, vS, R, gbM
931	Barnard (2998)	13 38 37	2·23	33 40·5	18·2	F, vS, R, gbM
932	Barnard (2998)	13 38 37	2·23	33 39·5	18·2	vS; R
933	J. 257	13 38 41	2·82	66 3·6	18·2	vF, vS, R, N = 13m, stellar
934	Barnard (2998)	13 38 50	2·23	33 40·5	18·2	F, vS, R
935	Barnard (2998)	13 38 51	2·23	33 41·5	18·2	F, vS, R, gbM
936	Barnard (2998)	13 38 51	2·23	33 40·5	18·2	F, vS, R
937	Barnard (2998)	13 39 20	2·23	33 39·0	18·2	vS
938	Barnard (2998)	13 39 23	2·23	33 40·5	18·2	vS
939	J. 258	13 40 40	3·03	85 54·6	18·1	pB, vS, bM
940	J. 259	13 40 56	3·03	85 52·3	18·1	vF, vS, dif
941	J. 260	13 42 2	2·80	65 18·0	18·1	F, eS, gbM, r
942	Sw. VII.	13 42 40	2·17	32 40·8	18·0	eF, pS, R
943	J. 261	13 43 27	3·03	86 6·9	18·0	pF, iF, lbM, F ✱ close
944	Sw. VII. and VIII.	13 44 42	2·92	75 12·2	18·0	vF, pS, mE, 3st f
945	Sw. VII.	13 45 2	1·18	17 14·9	18·0	eeF, S, R, 2st nf
946	Sw. VII. and VIII.	13 45 22	2·92	75 11·0	17·9	eF, vS, R, ✱ close f
947	J. 774	13 45 29	3·06	88 28·9	17·9	pB, vS, R, sbMN = 12m
948	Sw. VII. and VIII.	13 45 37	2·92	75 11·5	17·9	eF, S, R
949	Sf. 14	13 45 38	2·82	66 46·0	17·9	pF
950	J. 262	13 45 39	2·91	74 48·0	17·9	F, eS, R, lbM
951	Sw. VII.	13 46 29	2·30	38 20·0	17·9	eeF, pS, R, 2st nr sp
952	J. 263	13 46 37	3·03	85 57·4	17·9	F, Epf, F ✱ inv
953	O. St.	13 46 57	3·42	119 39·8	17·9	vF, eS, gbM
954	Sw. VII.	13 47 1	+1·24	18 7·4	+17·9	eeF, S, R, B ✱ f

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
955	O. St.	13 47 43	+3·42	119 34·4	+17·8	vF, vS, gbM
956	J. 264	13 48 2	2·83	68 35·8	17·8	eF, vS, ✶14n
957	O. St.	13 48 7	3·42	119 33·0	17·8	vF, S, gbM
958	Sw. IX.	13 48 45	3·01	84 16·7	17·8	eeF, pS, iR
959	Sw. VIII.	13 49 17	2·92	75 47·9	17·8	eeF, S, R
960	J. 265	13 49 18	2·87	71 47·2	17·8	F, pL, lbM, dif
961	J. 266	13 49 21	2·76	63 27·8	17·8	vF, S, dif
962	Sw. VIII.	13 50 27	2·93	77 16·0	17·7	pF, vS, R, bM
963	J. 267	13 50 42	2·87	71 54·3	17·7	eF, vS, R
964	J. 268	13 51 0	2·87	71 48·0	17·7	eF, eS, R
965	J. 269	13 51 7	2·87	71 48·0	17·7	vF, vS, R, vSN
966	J. 775	13 51 12	3·01	83 55·2	17·7	F, S, R, gbM, r
967	J. 270	13 51 35	2·90	74 51·5	17·7	pF, vS, R, ✶14 nr
968	B. 181	13 53 23	3·10	92 16	17·6	vF, vS, stellar
969	J. 776	13 54 30	3·11	93 30·2	17·6	vF, vS, R, N = 14m
970	J. 271	13 55 49	2·89	74 47·3	17·5	pB, vS, R
971	Sf. 105	13 56 23	3·18	99 27·7	17·5	No description
972	J. 272	13 56 46	3·26	106 33·0	17·5	F, vS, R, r
973	B. 182	13 59 10	3·13	94 49	17·4	Stellar, 13·5 m } Not obs by T
974	B. 183	13 59 15	3·13	94 51	17·4	Neb object 1′·8 sff of 5465 } Not obs by T
975	J. 273	14 0 26	2·88	73 58·8	17·3	vF, vS, R
976	Sw. VII.	14 1 28	3·08	90 28·5	17·3	eF, vS, R, eF ✶att s
977	J. 777	14 1 28	3·10	92 20·2	17·3	vF, S, dif
978	J. 778	14 1 44	3·10	92 18·4	17·3	vF, S, R, bMN
979	Sw. X.	14 2 34	2·88	74 29·5	17·2	eeF, pS, R, v diffic
980	J. 779	14 3 0	3·15	96 40·8	17·2	F, S, R, N = 13m, r
981	J. 780	14 3 11	3·11	93 30·6	17·2	F, S, gbM
982	J. 274	14 3 21	2·85	71 39·5	17·2	vS, R, N = 11m
983	J. 275	14 3 27	2·85	71 37·2	17·2	eS, R, N = 11m
984	J. 276	14 3 31	2·83	70 57·5	17·2	pB, S, gbM
985	O. St.	14 4 18	3·09	92 33·6	17·8	eF, eS
986	J. 781	14 4 19	3·05	88 0·5	17·1	F, S, N = 13·5, r
987	J. 277	14 4 56	2·82	70 9·2	17·1	eF, vS, stellar, v diffic
988	J. 278	14 7 28	3·02	86 9·8	17·0	F, vS, R
989	J. 279	14 7 48	3·02	86 12·5	17·0	F, vS, R, bM
990	B. 184	14 10 6	2·46	49 33	16·9	vF, S, dif
991	J. 280	14 10 14	3·24	103 13·3	16·9	F, S
992	J. 782	14 11 6	3·05	88 29·2	16·9	F, pS, R, ✶10·5 nf
993	J. 281	14 11 20	2·92	78 4·9	16·8	vF, iF, diffic
994	J. 282	14 11 24	2·92	78 8·5	16·8	pB, vS, R
995	Sw. VII.	14 12 5	1·85	31 32·4	16·8	eeF, S, lE, v diffic
996	Sw. VII.	14 12 37	+1·85	31 42·4	+16·8	eeF, S, mE, v diffic

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
997	Sw. (X.)	14 12 38	+3·12	93 50·0	+16·7	pF, S, R, ✱ n
998	Sw. (X.)	14 12 56	3·12	93 49·0	16·7	eeF, S, R, v diffic
999	J. 283	14 12 59	2·82	71 28·9	16·7	F, vS, R, N = 14m, stellar
1000	J. 284	14 13 7	2·82	71 30·1	16·7	F, vS, R, N = 14m, stellar
1001	J. 285	14 13 41	3·00	84 13·7	16·7	eF, S, dif
1002	J. 286	14 13 44	3·00	84 10·2	16·7	eF, vS, lbM
1003	J. 287	14 13 53	2·99	83 54·3	16·7	eF, vS, vS ✱ att, diffic
1004	J. 288	14 14 16	2·83	71 42·1	16·7	pF, sbM
1005	Sw. VII.	14 16 30	0·75	17 45·6	16·6	F, S, R, bM
1006	Sf. 15	14 16 32	2·73	65 34·2	16·6	F
1007	J. 289	14 17 36	3·00	84 48·8	16·5	vF, vS, R, lbM, ✱ 10·5 nr
1008	Sf. 5	14 18 52	2·65	61 1·8	16·5	pF
1009	J. 290	14 19 33	2·90	77 0·5	16·4	vF, S, dif
1010	J. 783	14 20 14	3·05	88 20·4	16·4	F, S, dif
1011	J. 784	14 20 58	3·05	88 21·7	16·3	F, vS, R, N = 14m
1012	Sf 8	14 21 10	2·60	58 23·4	16·3	No description
1013	J. 291	14 21 35	2·67	62 32·4	16·3	eF, vS
1014	Sf. 78	14 21 36	2·87	75 35·6	16·3	F, pL, R, vgbM
1015	J. 292	14 21 41	2·85	73 57·1	16·3	vF, iF
1016	Sw. X.	14 21 50	3·00	84 32·7	16·3	vF, vS, R, f h 1806
1017	J. 293	14 21 52	2·69	63 30·5	16·3	pF, vS, sbM, stellar
1018	J. 294	14 21 57	2·69	63 32·8	16·3	eF, eS, v diffic
1019	J. 295	14 21 59	2·69	63 25·8	16·3	F, vS, R, stellar, ✱ 13 nr
1020	J. 296	14 22 35	2·68	63 21·3	16·2	F, stellar, vF ✱ close
1021	J. 297	14 22 51	2·77	68 42·8	16·2	F, S, iR
1022	J. 298	14 23 0	3·01	85 34·9	16·2	vF, E ns
1023	Thome	14 23 55	3·63	125 10·6	16·2	Neb
1024	J. 299	14 24 26	3·02	86 21·9	16·2	pB, vS, E ns
1025	J. 300	14 24 33	2·97	82 17·7	16·2	eF, sbM
1026	Sf. 13	14 25 14	2·58	58 9·3	16·1	pB
1027	Sw. VII.	14 25 16	1·96	35 25·5	16·1	eeF, pS, R, another nr?
1028	Sw. VIII.	14 27 5	2·34	47 32·2	16·0	pB, S, R, F ✱ close nf
1029	B. 185	14 27 37	2·09	39 28	16·0	vF, S, lE, mbM
1030	Sf. 6	14 27 44	2·56	57 41·3	16·0	pF
1031	Sw. VII.	14 29 35	2·15	41 21·0	15·9	eeF, S, R
1032	Sw. VII.	14 29 40	2·15	41 25·7	15·9	eeF, S, R
1033	Sw. VII.	14 29 45	2·15	41 27·0	15·9	eeF, S, R
1034	J. 301	14 30 35	2·85	74 43·5	15·8	vF, lbM
1035	J. 302	14 31 20	2·93	80 3·3	15·8	pF, vS, R, S ✱ nr
1036	J. 303	14 31 52	2·80	71 16·5	15·8	pF, S
1037	J. 304	14 31 55	2·30	71 12·1	15·7	F, vS, R, stellar
1038	J. 305	14 32 42	+2·89	77 28·1	+15·7	F, vS, stellar, ✱ 10 f 8ˢ

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1039	J. 306, Sw. (X.)	14 33 27	+3·02	85 59·5	+15·7	vF, vS, lbM
1040	J. 307	14 33 34	2·93	79 55·5	15·7	eF, vS
1041	J. 308	14 33 35	3·02	86 2·9	15·7	pB, vS, R, N = 12m
1042	J. 309, Sw. (X.)	14 33 36	3·01	85 57·3	15·7	vF, vS, R, bM, close D with h 1862
1043	J. 310	14 33 41	3·01	86 3·0	15·7	vF, vS, R, bM
1044	J. 311	14 34 39	2·93	79 57·5	15·7	F, vS, R, gbM
1045	Sw. VIII.	14 35 26	2·31	46 39·4	15·6	eeF, pS, R, nearly bet 2 st
1046	Sw. VII.	14 35 53	0·82	20 22·4	15·5	eF, S, R, D ✱ f
1047	J. 313	14 35 53	2·77	70 12·7	15·5	vF, S, v dif
1048	J. 312	14 36 0	2·99	84 30·6	15·5	pB, pL, E pf, r
1049	Sw. IX.	11 36 11	1·45	27 22·1	15·5	eeF, pS, R
1050	J. 314	14 37 37	2·79	71 22·7	15·4	vF, S, R, dif
1051	J. 315	14 37 43	2·77	70 22·8	15·4	F, vS, stellar
1052	J. 316	14 37 48	2·74	68 47·5	15·4	Neb ✱ 12m
1053	J. 317	14 39 12	2·80	72 27·3	15·3	eF, vS, v dif, ✱ 4 mp 28s
1054	J. 785	14 39 24	3·04	88 8·6	15·3	vF, vS, sbMN = 14m
1055	J. 318	14 39 47	3·27	103 7·5	15·3	F, pL, E ns
1056	Sw. VII.	14 41 3	2·01	39 0·7	15·2	eeF, L, R, 3 pB st sf
1057	Sw. VII.	14 41 20	2·01	39 2·3	15·2	eF, pS, R, bet 3 st
1058	J. 319	14 42 42	2·79	72 22·8	15·2	F, E ns, mbMN = 14m
1059	J. 786	14 43 31	3·08	90 17·5	15·1	F, S, lbM, r
1060	Sf. 106	14 44 26	3·17	96 39·6	15·0	No descr
1061	J. 320	14 44 47	2·77	70 39·9	15·0	eF, eS, diffic
1062	J. 321	14 44 50	2·77	70 44·2	15·0	pF, iF, diffic
1063	J. 322	14 45 12	2·99	84 44·4	15·0	pF, stellar
1064	J. 323	14 45 13	2·99	84 45·6	15·0	vF, vS, R, lbM
1065	Sw. VII.	14 46 1	1·97	26 9·6	15·0	vF, pS, R
1066	J. 324	14 46 1	3·01	86 8·0	15·0	F, vS, R
1067	J. 325	14 46 5	3·01	86 6·0	15·0	F, vS, R, bM
1068	J. 326	14 46 30	3·01	86 21·4	15·0	F, pL, dif
1069	Sw. VII.	14 46 48	1·81	35 2·8	15·0	pF, vS, R, no st nr
1070	J. 327	14 46 53	3·01	85 56·6	15·0	vF, S, R, diffic
1071	Sw. X.	14 47 10	2·99	84 42·6	15·0	vF, S, R, bM
1072	J. 328	14 47 13	2·99	84 35·0	15·0	vF, vS, R, vlbM, 2nd of 3
1073	J. 329	14 47 15	2·99	84 37·9	15·0	vF, S, R, S ✱ s, 3rd of 3
1074	Sw. VII.	14 47 27	1·94	38 9·3	14·9	eeF, S, R
1075	Sw. VIII.	14 48 22	2·77	71 18·3	14·8	eeF, pS, R, v diffic
1076	Sw. VIII., J. 330	14 48 32	2·77	71 23·1	14·8	eF, pS, R, bM, ✱ sp
1077	O. St.	14 49 28	3·38	108 44	14·8	vF, vS, R, gbMN
1078	J. 331	14 49 42	2·91	80 5·2	14·8	pF, vS, R, lbM
1079	J. 332	14 49 49	+2·91	80 4·3	+14·7	F, vS, R, gbM

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		h m s	s	° ′	″	
1080	J. 787	14 50 36	+3·17	96 9·6	+14·7	vF, vS, R, lbM
1081	O. St.	14 50 59	3·38	108 44	14·7	eF, pL, E 175°
1082	J. 333	14 52 0	2·95	82 25·4	14·6	pF, S, R
1083	Sw. VII.	14 53 39	0·69	21 0·6	14·5	eeF, S, R
1084	O. St.	14 53 48	3·18	96 55·0	14·5	eF, S, R, dif
1085	J. 334	14 56 15	2·77	72 12·9	14·4	pB, vS, lE ns
1086	J. 335	14 56 58	2·77	72 21·7	14·3	F, iR, bMN
1087	J. 336	14 59 40	3·00	85 41·8	14·1	vF, vS
1088	J. 337	14 59 44	3·00	85 40·9	14·1	eeF, vS
1089	J. 338	15 0 32	2·94	82 21·4	14·1	eF, vS, R
1090	B. 186	15 0 38	2·18	46 47	14·1	eF, neb?
1091	B. 187	15 0 39	3·25	100 36	14·1	vF, S, dif
1092	J. 339	15 0 49	2·90	80 5·8	14·4	vF, vS, R
1093	J. 340	15 1 2	2·82	74 56·3	14·1	pB, vS, R, lbM
1094	J. 341	15 1 9	2·82	74 51·8	14·1	pB, vS, R, biN
1095	Sw. VIII.	15 1 55	2·83	75 27·0	14·0	eeF, S, lE
1096	J. 342	15 1 58	2·73	70 16·6	14·0	vF, S, dif
1097	J. 343	15 2 8	2·73	70 17·1	14·0	vF, vS, R, lbM
1098	B. 188	15 2 36	1·65	33 51	14·0	vF (? only a ✱ 13m)
1099	Sw. IX.	15 3 22	1·60	32 58·2	13·9	eeF, pS, R, bet 2F st
1100	Sw. IX.	15 3 30	1·15	26 28·2	13·9	vF, pS, lE, bet 2 st
1101	Sw. IX.	15 4 1	2·97	83 42·2	13·8	No descr
1102	Sw. X.	15 4 10	2·99	85 12·0	13·8	eeF, vS, F ✱ sf, v diffic
1103	J. 344	15 5 17	2·73	70 15·9	13·8	vF, S
1104	B. 190	15 5 29	3·15	94 33	13·8	vF
1105	Sw. X.	15 6 20	2·99	85 12·6	13·7	eeF, S, lE, F ✱ np
1106	J. 345	15 6 58	2·98	84 45·8	13·7	vF, vS, R, gbM
1107	J. 346	15 7 11	2·98	84 45·6	13·7	F, vS, R, gbM
1108	Fleming (3269)	15 7 18	4·06	135 8	13·6	Stellar, gaseous spectrum
1109	Sw. X.	15 10 6	2·97	84 14·7	13·5	eeF, pS, R, ✱ nf, v diffic
1110	Sw. VII.	15 10 12	0·65	22 6·6	13·5	eeF, S, mE
1111	Sw. VIII.	15 10 30	1·66	34 57·2	13·5	pB, S, R, 2 st nr
1112	Sw. IX.	15 10 52	2·94	82 15·3	13·4	eeF, pS, R
1113	J. 347	15 11 38	+2·84	76 58·9	13·4	eF, ✱ 12 nr
1114	B. 191	15 13 13	−0·88	14 2	13·4	vF, ? only a ✱ 13
1115	Sw. VIII.	15 15 1	+3·14	93 57·4	13·2	eeF, S, R, pB ✱ sf
1116	Sw. IX.	15 15 13	2·91	81 3·5	13·1	eeF, S, R
1117	J. 348	15 17 54	2·78	74 3·2	12·9	F, vS, R, lbM
1118	J. 349	15 18 24	2·82	76 3·4	12·9	pB, vS, R, S ✱ nr
1119	J. 788	15 18 26	3·13	93 9·7	12·9	F, pS, R, ✱ 11·5 nf
1120	J. 350	15 19 51	2·72	70 38·6	12·9	eF, eS, vF ✱ att
1121	Sw. IX.	15 20 52	+2·94	82 41·6	+12·8	eeF, eS, stellar, vF ✱ close p

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1122	{B. 192, Barnard (3004)}	15 22 36	+2·93	81 55·6	+12·7	vF, pS, mbM, ✱ 11 p 1′
1123	B. 193	15 24 3	2·09	46 38	12·6	vF, eS, stellar
1124	Sw. VIII.	15 24 27	2·61	65 52·1	12 5	eeF, vS, mE, 2 st n
1125	J. 789	15 25 50	3·09	91 8·6	12·4	F, pL, R, dif
1126	B. 194	15 28 4	2·97	84 32	12·3	✱ 13, nebulous?
1127	Sf. 7	15 29 50	2·60	65 3·2	12·1	pF
1128	Sw. VIII.	15 30 42	3·09	91 4·8	12·1	pF, pS, R
1129	Sw. VII.	15 31 5	0·35	21 16·5	12·1	vF, pS, iR, D ✱ nf
1130	B. 195	15 31 20	2 73	72 18	12·0	vF (? another 2′ sp), ✱ 8·7 f
1131	J. 351	15 32 14	2·83	77 27·4	12 0	pF, vS, R, stellar, II. 76 np
1132	Sf. 9	15 33 42	2 66	68 52·9	11·9	No descr
1133	J. 352	15 34 43	2·76	73 58·4	11·8	pB, pL, iF
1134	J. 353	15 38 34	2 73	72 34·8	11 6	vF, vS, dif
1135	J. 354	15 39 12	2·71	71 52·1	11·5	vF, vS, R
1136	J. 790	15 40 18	3·09	91 7·2	11·4	F, eS, stellar
1137	Sw. IX.	15 42 8	2·90	80 59·0	11·3	vF, S, R, ✱ 9 close np
1138	J. 355	15 42 23	+2·52	63 22·3	11·3	vF, S, iF, lbM, r
1139	Sw. VII.	15 42 43	−5·84	6 56·6	11·4	eeF, S, lE, v diffic
1140	B. 196	15 42 52	+2·68	70 30	11·2	vF (? S Cl), ✱ 9·5 close
1141	Sw. VII.	15 43 3	2·82	77 10 3	11·2	vF, vS, R
1142	J. 356	15 43 8	+2·70	71 24·9	11·2	vF, dif
1143	Sw. VII.	15 43 56	−5·70	7 5·6	11·4	pF, vS, R, ✱ nr
1144	Sw. IX.	15 46 43	+2·00	46 7 9	11·0	eeF, vS, R, ✱ sf
1145	Sw. VII.	15 47 22	−0·48	17 6 9	11·0	eeF, pS, R, III. 313 nr
1146	Sw. VII.	15 48 9	+0·04	20 10·3	11 0	vF, pS, R, 2 st nr, sp of 2
1147	Sw. VII.	15 49 55	0·00	20 0·4	11·8	eeF, S, R, nf of 2
1148	Sf. 10	15 50 49	2·60	67 11·0	10 6	Neb ✱
1149	Sw (X.)	15 51 25	2 82	77 30·9	10·6	eeF, pS, R, am 4st, v diffic
1150	J. 357	15 51 53	2 74	73 43·7	10·6	2 S st in F neby
1151	J. 358	15 52 12	2·71	72 8 7	10·5	vF, pL, dif
1152	Sw. VII.	15 52 21	1·79	41 30·2	10·5	vF, S, R, sp of 2
1153	Sw. VII.	15 52 36	+1·79	41 25·4	10·5	pF, pS, R, bM, ✱ nf, nf of 2
1154	Sw. VII.	15 52 45	−0·16	19 13·1	10·5	vF, pS, R
1155	J. 359	15 54 12	+2·72	73 54·5	10·4	vF, S, diffic
1156	Sw. VII.	15 54 25	2·66	69 52·7	10 3	eeF, pS, lE, 2 st nr
1157	J. 360	15 54 31	2·75	74 4·9	10·3	vF, vS
1158	Sw. X.	15 54 34	3 03	87 53·5	10·3	eeF, pL, iR
1159	J. 361	15 54 36	2·75	74 11·5	10·3	vF, eS, R
1160	J. 362	15 54 39	2·75	74 7·1	10·3	vF, vS, R
1161	J. 363	15 54 52	2·74	73 57·1	10·3	F, vS, R, vSN
1162	J. 364	15 54 57	+2·70	71 55·2	+10·3	vF, vS, R, diffic (another susp)

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		h m s	s	° ′	″	
1163	J. 365	15 55 5	+2·74	74 6·5	+10·3	F, R, vSN
1164	B. 197	15 55 34	−0·24	19 1	10·3	✱ 13 with neb ?
1165	J. 366	15 55 44	+2·74	73 54·2	10·2	vF, S, diffic
1166	J. 367	15 56 20	2·50	63 18·7	10·2	vF, vS, vF✱nf
1167	J. 368	15 57 25	2·75	74 39·7	10·2	F, vS, R
1168	J. 369	15 57 28	2·75	74 42·3	10·2	pF, vS, iF, D ?, 3 F st n
1169	Sw. VII. & VIII.	15 57 47	2·78	75 51·3	10·2	eF, vS, stellar
1170	J. 370	15 58 13	2·69	71 53·2	10·1	vF, vS, vSFN, 6041 f
1171	B. 198	15 58 33	2·69	71 39	10·1	Neb✱?
1172	B. 199	15 58 42	2·69	71 45	10·1	vF, S, stellar N
1173	J. 371	15 58 55	2·70	72 12·2	10·0	pF, S, iF, gbM, r
1174	Sf. 77	15 59 0	2·75	74 35·4	10·0	pF, S, bMN = 12m
1175	B. 200	15 59 1	2·69	71 29	10·0	Neb object, 6055 f 2′
1176	Sw. VII.	15 59 4	2·69	71 39·7	10·0	eeF, pS, iR, 2st nr s
1177	B. 201	15 59 5	2·68	71 18	10·0	vF, ✱9·5 4′ s
1178	Sw. VII.	15 59 7	2·70	72 1·2	10·0	eeF, pS, bet 2st
1179	Sw. VII.	15 59 7	2·69	71 52·0	10·0	eeF, pS, R [? = 6054]
1180	B. 202	15 59 9	2·69	71 30	10·0	F✱ with neb ?, 6055 f
1181	Sw. VII.	15 59 16	2·70	72 1·7	10·0	eeF, S, R, '12th of 12'
1182	J. 372	15 59 19	2·69	71 48·8	10·0	vF, S, dif, lbM
1183	B. 203, J. 372 *a*	15 59 19	2·69	71 51	10·0	vF, vS, stellar✱11 sp 1′
1184	B. 204	15 59 25	2·69	71 49	10·0	✱13 with neb ?
1185	B. 205	15 59 26	2·69	71 54	10·0	✱13 with S neb
1186	J. 373	15 59 27	+2·70	72 15·8	10·0	F, S, dif
1187	B. 206	15 59 34	−0·27	19 3	10·0	✱13 with neb
1188	J. 374	15 59 50	+2·70	72 9·9	10·0	vF, S, dif
1189	Sw. VII.	15 59 55	2·68	71 25·7	10·0	eeF, pS, iR, bet 2 st
1190	Sw. VII.	16 0 5	2·68	71 22·3	10·0	eeF, S, R, 6061 nr
1191	Sw. VII.	16 0 7	2·68	71 20·7	10·0	eeF, S, lE
1192	J. 375	16 0 16	2·69	71 50·4	10·0	vF, S, iF, dif
1193	J. 376	16 0 16	2·69	71 53·1	10·0	F, S, r
1194	J. 377	16 0 21	2·69	71 50·1	9·9	eF, vS, dif
1195	J. 378	16 0 23	2·71	72 26·2	9·9	vF, S, dif
1196	Sw. VII.	16 1 19	2·85	78 51·0	9·8	eeF, nr p✱of 3 in line
1197	Spitaler (2993)	16 1 31	2·91	82 4·2	9·8	L, mE, ✱att nf
1198	J. 379	16 2 2	2·81	77 16·9	9·8	F, vS, R, N = 13m
1199	Sw. IX.	16 3 54	+2·86	79 35·4	9·7	eeF, S, E, ✱9·5 f 9ˢ
1200	Sw. VII.	16 4 44	−0·15	19 57·0	9·7	pF, pS, lE, ✱12 nr [? = B 207]
1201	Sw. VII.	16 5 59	−0·15	20 1·0	9·6	eeF, pS, iR, v diffic
1202	Sw. VII.	16 6 14	+2·86	79 46·1	9·5	eF, pS, R
1203	Thome	16 6 58	+3·55	111 59·1	9·4	No descr
1204	B. 207	16 7 34	−0·16	20 1	+9·5	vF, S, stell N, ✱11 f 3′

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1205	Sw. VII.	16 7 40	+2·87	80 7 2	+9·3	F, S, lE, ✱ p
1206	Sw. VII., B. 208	16 8 36	2·83	78 20·8	9·3	eF, S, R
1207	Thome	16 10 41	3·74	119 17·9	9·1	No descr
1208	Burnham	16 10 43	2·18	53 7·3	9·1	vF, ✱ 7m 105″ n
1209	J. 380	16 12 17	2·73	74 5·9	9·0	pF, vS, R, bM, r
1210	Sw. IX.	16 12 40	0·75	27 6·5	9·0	vF, vS, lE, r
1211	Sw. VIII.	16 13 26	1·46	36 38·7	8·9	pB, vS, R, bM
1212	Sw. IX.	16 14 13	0·56	25 25·7	8·9	eeF, pS, R, 3st n in line
1213	Sw. IX.	16 14 47	3·10	91 11·4	8·8	F, vS, R
1214	Sw. VII.	16 15 20	0·34	23 40·8	8·8	eF, S, R
1215	Sw. VII.	16 15 30	0·01	21 15·0	8·8	vF, S, R, 1st of 3
1216	Sw. VII.	16 15 55	+0·01	21 18·4	8·8	eeF, pS, R, 2nd of 3
1217	Sw. VII.	16 16 32	−0·23	19 59·0	8·7	eeF, S, R, v diffic
1218	Sw. VII.	16 16 40	0·00	21 26·7	8 7	vF, pS, lE
1219	J. 381	16 18 17	+2 63	70 11·6	8·5	F, S, Epf, lbM
1220	Sw. X.	16 22 29	2·89	81 13·9	8·2	eeF, pS, E
1221	Sw. X.	16 30 38	1·76	43 17·9	7·6	eeF, pS, E, p of 2
1222	Sw. X.	16 30 57	1·77	43 28 9	7 6	eeF, pL, R, f of 2
1223	Sw. X.	16 31 36	1·62	40 26·9	7·5	eeF, pS, R, bet 2 dist F st
1224	J. 382	16 36 48	2·63	70 29·3	7·1	vF, vS, R, stellar
1225	Sw. IX.	16 37 0	0·00	22 5·3	7·1	eeF, vS, 2 or 3 F st inv, ✱ p
1226	Sw. IX.	16 37 2	1·76	43 43·2	7·0	eF, S, R, forms arc with 4 st
1227	B. 210	16 37 45	0·99	31 7	7·0	vF, S, R, stellar N
1228	Sw. X.	16 41 30	0·27	24 9·2	6·7	vF, pS ✱ n, 4 st in curve s
1229	Sw. X.	16 41 30	1·49	38 27·2	6·7	eeF, pS, v diffic, np of 2
1230	Sw. X.	16 41 48	1·49	38 31·2	6·7	eeF, S, R, v diffic, sf of 2
1231	Sw. IX.	16 44 40	0·99	31 18·8	6·4	eeF, L, R, pB ✱ sp
1232	Sw. IX.	16 45 ±	1·75	43 40·2	6·3	eeF, S, iR, B ✱ sf
1233	Sw. IX.	16 47 9	0·54	26 36·6	6 3	eF, vS, vE, bet 2 st [= 6247 ?]
1234	B. 211	16 50 17	1·10	32 52	6·0	vF, sev st in neb ?
1235	B. 212	16 50 49	0·53	26 39	6·0	vF, dif, pS, ✱ 8 nf 3′
1236	Sf. 44, Sw. X.	16 52 29	2·60	69 43·6	5·7	eF, pS, vlE, vF ✱ close p
1237	Sw. IX.	16 53 23	1·22	34 43·8	5·7	eF, pL, lE, ✱ nr p
1238	m. 327	16 54 40	2·52	66 42	5 6	eF (not obs by St)
1239	B. 213	16 54 51	2·52	66 46	5·6	eF, eF stell N [6276 ?]
1240	B. 214	16 59 19	0·72	28 45	5·1	Susp neb, 3′ nf ✱ 8·7
1241	Sw. VII.	17 0 27	0·44	26 5·8	5·1	eF, pS, R
1242	J. 383	17 1 46	2·98	85 46·2	5·0	vS, R, vlbM
1243	Sw. IX.	17 4 0	2·82	79 1·9	4·8	pF, pS, mE, r
1244	Sw. VIII. & IX.	17 5 32	2·11	53 33·8	4·7	vF, pS, R, bet 2 st
1245	Sw. IX.	17 7 43	2·05	51 47·7	4·6	eF, S, R, bM, F ✱ close s
1246	B. 215	17 8 13	+2·59	69 36	+4·4	Neb ✱ 13 ? ✱ 10 n 1′

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		h m s	s	° ′	″	
1247	B. 216	17 8 31	+3.36	102 38	+4.3	Stellar, ✱ 9.8 sp 0′.7
1248	Sw. VII.	17 9 26	0.81	29 57.5	4.4	eeF, pS, R, bet 2 st p & f
1249	Sw. IX.	17 9 56	2.13	54 17.8	4.3	eeF, pS, R, v diffic, 4 st s
1250	Sw. IX.	17 12 4	+1.02	32 25.2	4.1	pF, S, cE
1251	Sw. X.	17 12 49	−1.09	17 25.0	4.1	eeF, pS, R, sp of 2, II. 767 nr
1252	B. 217	17 13 26	+1.02	32 28	4.0	vF, pS, ✱ 12.5 v close
1253	Sf. 29	17 13 39	+2.67	71 11.4	3.9	F
1254	Sw. X.	17 14 21	−1.09	17 24.5	4.0	eeF, pS, R, nf of 2, v diffic
1255	Sw. X.	17 16 37	+2.78	77 12.1	3.7	vF, pS, R, forms trap with 3 st
1256	J. 384	17 18 9	2.41	63 23.7	3.7	F, S, gbM
1257	Spitaler (2993)	17 19 36	3.23	96 58.2	3.4	F, pL, lbM
1258	Sw. VII.	17 25 3	0.91	31 23.3	3.0	pB, pS, R, 1st of 3
1259	Sw. VII.	17 25 13	0.91	31 20.8	3.0	pB, pS, R, 2nd of 3
1260	Sw. IX.	17 25 18	+0.91	31 24.2	3.0	eeF, S, R, 3rd of 3
1261	Sw. VIII.	17 25 25	−0.85	18 36.0	3.0	eeF, pS, R
1262	Sw. IX.	17 28 51	+1.80	46 7.7	2.7	eF, pS, R, 1st of 3
1263	Sw. IX.	17 28 56	1.80	46 4.7	2.7	eF, pS, R, 2nd of 3
1264	Sw. IX.	17 29 6	1.80	46 15.2	2.7	eF, pS, R, 3rd of 3
1265	Sw. IX.	17 32 21	1.87	47 48.5	2.4	eeF, S, lE
1266	Pickering (3227)	17 35 14	4.45	136 2	2.1	Stellar (gaseous spectrum)
1267	Sw. VII.	17 36 45	0.82	30 32.3	2.0	eeF, pS, R, v diffic
1268	Sw. VII.	17 44 12	2.66	72 44.9	1.3	eeF, pS, R, v diffic
1269	Sw. VII.	17 46 29	2.54	68 25.9	1.1	eeF, pL, R, 2 F st nr
1270	Sw. VII.	17 46 32	0.53	27 43.9	1.2	eeF, S, R, v diffic, 6488 f
1271	Sw. VIII.	17 56 55	3.68	114 27.2	+0.2	eeF, vL, B✱ inv
1272	B. 218	17 59 11	2.44	64 55	0.0	S Cl
1273	B. 219	17 59 20	2.44	64 53	0.0	vF, S Cl with neb? ✱ 10 f 3′
1274	Barnard (3111)	18 1 0	3.66	113 45	−0.2	3 st 8.5 to 9m in pL neb
1275	Barnard (3111)	18 1 25	3.67	113 51	0.2	2 st 8 & 8.5 in pL neb
1276	Sw. VIII.	18 3 33	3.24	97 15.4	0.4	eeF, vL, v diffic, D✱ close p
1277	B. 220	18 4 56	2.30	59 2	0.5	S Cl
1278	B. 221	18 5 11	2.27	58 53	0.6	vF, vS, sev st susp
1279	Sw. VII.	18 6 12	2.10	53 59.8	0.6	eeF, pS, R, v diffic
1280	B. 222	18 6 38	2.43	64 22	0.6	✱ 13, nebulous?
1281	Sw. VIII.	18 6 42	2.10	54 0.4	0.6	eeF, S, cE, sev st nr f [? = 1279]
1282	B. 223	18 8 6	2.56	68 56	0.8	vF, 2 or 3 st susp
1283	Barnard (3111)	18 8 59	3.55	109 47.0	0.8	✱ 9.3 nebulous
1284	Barnard (3101)	18 9 23	3.55	109 42.7	0.8	✱ 7.6 in neb, 15′ diam
1285	B. 224	18 10 26	2.45	64 57	1.0	S Cl
1286	Sw. VII.	18 13 41	1.13	34 27.4	1.2	eF, pS, R, 2 st nr
1287	Barnard (3111)	18 23 40	3.33	100 53.2	2.1	✱ 5.5 in L, E neb
1288	Sw. VII.	18 24 41	+1.97	50 21.0	−2.1	v F, S, lE, 3 st nr

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1289	Sw. VII.	18 25 16	+1·96	50 6·0	−2·2	eeF, pS, lE, 3 st nr
1290	Thome	18 29 55	3·67	114 13·7	2·5	No descr
1291	Sw. X.	18 30 3	1·56	40 47·4	2·7	eF, vS, R, F ✱ close n
1292	Fleming (3269)	18 35 58	3·77	117 57	3·1	Stellar, gaseous spectrum, ✱ 9·6 sf
1293	Sw. VIII.	18 39 7	1·10	33 49·4	3·4	eeF, S, lE, ✱ in centre, ?D
1294	Sw. VII.	18 45 16	1·97	49 54·9	4·0	eeF, S, iR, v diffic, F ✱ close nf
1295	Sf. 82	18 47 1	3·28	98 58·0	4·2	pB, pL, gbM
1296	Barnard (3200)	18 48 7	2·23	57 6·5	4·3	eF, pS, iR, 4′ npM 57
1297	Pickering (3227)	19 7 45	4·14	129 51	5·9	Stellar (gaseous spectrum)
1298	B. 225	19 11 16	3·11	91 52	6·2	vS Cl, 6778 p 3′
1299	Espin	19 16 33	2·60	69 31	6·7	S Cl of v F st
1300	Sw. X.	19 20 42	1·44	37 37·5	7·0	eF, vS, R
1301	Sw. IX.	19 22 56	1·63	40 59·6	7·2	eeF, vS, R, 3 st f
1302	Sf. 36	19 25 41	2·18	54 32·2	7·4	vF, undefined
1303	Sf. 37	19 26 16	2·17	54 26·2	7·4	vF, S, with S Cl
1304	Espin	19 30 46	2·01	49 16	7·8	F neby
1305	Espin	19 33 8	2·63	70 6	8·0	vF, ✱ 9·5 at sf end
1306	Espin	19 36 43	2·14	52 41	8·3	Neb group of F st
1307	Espin	19 37 5	2·45	62 50	8·3	F, vL, Ens, st inv
1308	O. St.	19 37 10	3·40	105 3·3	8·3	eF, eS, lE, gbM, 6822 p 12ˢ
1309	J. 385	19 55 1	3·44	107 37·1	9·7	F, vS, R, r
1310	Espin	20 4 43	2·29	55 27	10·4	F neb y
1311	Espin	20 6 0	2·09	49 14	10·6	eF, within circle of st
1312	B. 226	20 10 30	2·72	72 24	10·9	eF, pL, dif
1313	J. 386	20 10 45	3·42	107 22·9	10·9	F, vS, R, ✱ 13 close
1314	Espin	20 11 42	2·56	65 15	11·0	F, pL, partly resolved
1315	B. 227	20 11 43	2·41	59 45	11·0	✱ 13 with eF neb ?
1316	B. 228	20 15 33	2·95	83 55	11·3	eF neb, suspected
1317	Spitaler 23	20 16 7	3·07	89 46·8	11·3	○ = ✱ 12, diam 10″–15″
1318	Barnard	20 17 12	2·15	50 11·4	11·4	γ Cygni, surrounded by L patches of F neby
1319	J. 387	20 18 0	3·45	108 57·5	11·4	pF, vS, R, r
1320	J. 791	20 19 24	3·04	87 32·8	11·5	pF, S, R, gbM, r
1321	J. 388	20 20 10	3·44	108 44·7	11·6	F, S, iF, r
1322	J. 389	20 22 16	3·37	105 41·3	11·7	F, vS, R
1323	J. 390	20 22 37	3·37	105 38·7	11·7	vS neb ✱
1324	Sw. VII.	20 24 12	3·25	99 32·4	11·9	eeF, S, R, ✱ 8m s
1325	Sw. VIII.	20 26 6	2·89	80 35·8	12·0	vF, S, sev F st inv, sp of 2
1326	Sw. VIII.	20 26 16	2·89	80 34·9	12·0	eeF, S, mE, pF ✱ s, nf of 2
1327	Burnham	20 28 30	3·08	90 29·0	12·2	vF, ✱ 8m 1′f
1328	J. 391	20 33 54	3·45	110 7·8	12·6	F, S, vF ✱ close
1329	Sw. IX.	20 37 11	+2·79	74 54·9	−12·8	eeF, pL, R, bet 4 st, v diffic

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		h m s	s	° ′	″	
1330	J. 392	20 38 29	+3·34	104 31·9	−12·8	F, vS, dif
1331	J. 393	20 40 13	3·26	100 30·2	13·0	F, S, bM r
1332	J. 394	20 44 5	3·33	104 13·9	13·2	F, vS, R
1333	J. 395	20 44 25	3·37	106 46·1	13·3	vF, vS, sbM
1334	J. 396	20 44 26	3·37	106 48·1	13·3	F, S
1335	J. 397	20 45 15	3·37	106 51·2	13·4	F, S, stellar
1336	J. 398	20 47 10	3·40	108 34·1	13·5	vF, S, dif, F ∗ f
1337	J. 399	20 49 3	3·37	107 6·7	13·6	F, vS, R, gbM
1338	J. 400	20 49 7	3·37	107 1·8	13·6	vF, vS, dif
1339	J. 401	20 50 1	3·40	108 28·9	13·6	F, S, gbM, r
1340	Sf. 51	20 50 25	2·49	59 28·4	13·6	Possibly conn with h 2093
1341	J. 402	20 52 32	3·32	104 31·6	13·7	F, vS, R, lbM
1342	J. 403	20 52 41	3·33	105 2·5	13·7	vF, vS, Epf, lbM
1343	J. 404	20 53 23	3·35	105 56·6	13·8	pB, vS, R, mbM
1344	J. 405	20 53 32	3·31	103 55·3	13·8	pB, pL, iF, sbM
1345	J. 406	20 53 40	3·31	103 56·4	13·8	vF, S, R, vlbM
1346	J. 407	20 53 58	3·32	104 24·6	13·9	pB, vS, R, gbM
1347	J. 408	20 54 1	3·31	103 51·5	13·9	pB, R
1348	J. 409	20 54 1	3·31	103 54·1	13·9	F, vS, R, bM
1349	J. 410	20 54 7	3·31	103 48·4	13·9	vF, vS, R, lbM
1350	J. 411	20 54 8	3·32	104 23·6	13·9	F, S, iF, lbM, r
1351	J. 412	20 54 9	3·31	103 44·6	13·9	F, vS, R, lbM
1352	J. 413	20 54 12	3·31	103 55·7	13·9	pB
1353	J. 414	20 54 13	3·31	103 49·2	13·9	vF, vS, R
1354	J. 415	20 54 14	3·32	104 18·2	13·9	F, vS, R, bM
1355	J. 416	20 54 15	3·31	103 43·0	13·9	F, vS, R, bM
1356	J. 417	20 55 4	3·35	106 21·3	14·0	F, R, sbM
1357	J. 418	20 58 20	3·26	101 16·5	14·1	vF, vS, iF, vlbM
1358	J. 419	20 58 41	3·36	106 45·9	14·2	vF, vS
1359	Sw. IX.	21 1 59	2·87	78 5·2	14·4	eeF, eS, stellar, eF ∗ att
1360	J. 792	21 3 52	3·00	85 30·5	14·5	F, dif
1361	J. 793	21 4 31	3·00	85 31·6	14·5	vF, vS, dif
1362	Spitaler 24	21 4 47	3·04	88 14·5	14·5	vF, vS, R, ∗ 14 nf
1363	Espin	21 5 39	2·11	43 43	14·6	F, ∗ 9·4 at s end
1364	J. 420, Spitaler 25	21 6 20	3·03	87 48·6	14·6	pB, pS, R, sbM
1365	Spitaler 26, Sw. X.	21 6 51	3·04	88 1·0	14·7	eF, pS, R (Spit. another p?)
1366	Spitaler 27	21 7 2	3·04	88 48·0	14·7	F, S, iR, bet 2 st 11 & 13
1367	J. 421	21 7 7	3·03	87 34·9	14·7	vF, vS, R, F ∗ nr
1368	Sw. X.	21 7 9	3·04	88 24·9	14·7	eeF, S, R, v diffic
1369	Pechüle (3259)	21 7 17	2·09	42 49	14·7	S neb Cl of st 13m
1370	J. 422	21 8 8	3·05	88 23·7	14·8	vF, 2 F st inv
1371	J. 423	21 12 54	+3·16	95 27·9	−15·0	F, S, dif, gbM, r

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		h m s	s	° ′	″	
1372	J. 424	21 12 54	+3·17	96 12·0	−15·0	vF, vS, R, dif, ✳ 14 sf
1373	Spitaler 28	21 13 29	3·06	89 30·0	15·1	F, vS, R, sbM, 2 others south
1374	J. 425	21 13 56	3·05	88 52·9	15·1	vF, vS, lbM
1375	J. 426	21 13 57	3·02	86 36·0	15·1	F, S, 2 F st inv
1376	Sf. 85	21 17 18	3·17	96 20·6	15·3	No descr
1377	J. 427	21 18 26	3·01	86 16·6	15·3	pB, S, R
1378	Espin	21 18 44	1·85	35 9	15·3	F, dif, F st inv
1379	J. 428	21 18 54	3·03	87 30·4	15·4	vF, bM, stellar
1380	J. 429	21 20 6	3·04	87 54·0	15·4	pB, S
1381	J. 430	21 20 21	3·10	91 47·7	15·5	F, vS, R, bM
1382	Sf. 55	21 20 24	2·79	71 57·1	15·5	pF, pS, iF
1383	J. 431	21 20 27	3·10	91 42·6	15·5	F, vS, R, stellar
1384	J. 432	21 20 37	3·10	91 57·5	15·5	vF, vS, R
1385	J. 433	21 21 39	3·10	91 40·7	15·5	pB, vS, R
1386	J. 434	21 21 41	3·41	111 48·0	15·5	F, bi N, or neb D ✳
1387	J. 435	21 22 18	3·10	91 56·5	15·6	pB, vS, iF
1388	Sw. X.	21 22 42	3·09	91 16·6	15·6	eF, vS, 2 st nf
1389	J. 436	21 24 19	3·36	108 38·2	15·7	F, vS, R, gbM
1390	J. 437	21 25 9	3·11	92 28·6	15·7	F, vS, R, bM
1391	J. 438	21 27 50	3·09	91 7·4	15·8	vF, S, dif
1392	Sf. 50	21 29 43	2·51	55 13·5	15·9	pB, vmbM ✳
1393	O. St.	21 32 16	3·41	113 2·7	16·1	eF, vS, R, dif
1394	Sw. VIII.	21 33 24	2·87	75 59·6	16·2	eF, S, R
1395	J. 439	21 34 37	3·02	86 31·7	16·2	vF, vS, iF, lbM
1396	Barnard	21 34 40	1·86	33 10	16·2	Neb part of M. Way
1397	J. 440	21 36 42	3·15	95 31·5	16·3	F, vS, stellar
1398	Spitaler 29	21 38 59	2·95	81 10·1	16·4	vF, vS, bM
1399	J. 441	21 39 8	3·02	86 14·6	16·4	vF, vS, stellar
1400	Espin	21 39 19	2·08	37 42	16·4	F, dif, partly resolved
1401	J. 442	21 39 50	3·06	88 56·8	16·5	pB, pS, r
1402	Espin	21 39 59	2·07	37 23	16·5	F, partly res, st 14m
1403	J. 443	21 43 12	3·12	93 22·0	16·6	eF, S, F ✳ att, v diffic
1404	J. 444	21 43 29	3·20	99 55·4	16·7	F, vS, R, sbM ✳ 13
1405	J. 445	21 43 43	3·05	88 37·6	16·7	pB, vS, R, bM
1406	J. 446	21 43 58	3·05	88 39·6	16·7	F, vS, R, stellar
1407	J. 447	21 45 18	3·04	87 14·4	16·7	F, S, r
1408	J. 448	21 45 34	3·26	104 0·2	16·7	F, vS, R, bM
1409	J. 449	21 45 56	3·18	98 9·3	16·7	eF, S, iF
1410	J. 450	21 48 46	3·12	93 33·2	16·9	pF, vSN
1411	J. 451	21 48 48	3·10	92 10·6	16·9	F, vS, R, vlbM
1412	J. 452	21 50 38	3·30	107 50·7	17·0	F, vS, ? D stell neb
1413	J. 453	21 51 11	+3·12	93 46·2	−17·0	F, S, stellar

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1414	Spitaler 30	21 51 22	+2·97	82 16	−17·0	vF, vS, R, 2 F st s
1415	B. 229	21 51 36	3·06	89 19	17·0	eF, ✱9·5 sf 8′
1416	B. 230	21 52 26	3·06	89 13	17·1	eF trace of neby
1417	J. 454	21 52 47	3·25	103 48·7	17·1	pB, pL, part more condensed
1418	J. 455	21 54 56	3·03	86 18·0	17·2	vF, S
1419	J. 456	21 55 31	3·20	100 35·5	17·2	eF, slbM
1420	Sw. IX.	21 55 35	2·84	70 55·4	17·2	eeF, pS, R, bet 2 F st
1421	J. 457	21 55 37	3·20	100 39·0	17·2	Neb ✱ 14m
1422	J. 794	21 55 53	3·05	88 4·1	17·2	vF, eS, lbM, bet 2 st 13·5
1423	J. 458	21 56 10	3·03	86 22·6	17·2	F, vS, R, gvlbM
1424	B. 231	21 56 18	2·94	79 29	17·2	eF, vS, 1′ f 7190
1425	J. 795	21 56 19	3·05	88 4·4	17·3	F, lE pf, r, D ?
1426	J. 459	21 56 26	3·20	100 35·1	17·3	F, S, iF, lbM
1427	Sf. 52	21 56 34	2·90	75 33·6	17·3	vF, vS
1428	J. 796	21 57 21	3·05	88 2·3	17·3	vF, S, R, ✱14 nr
1429	B. 232	21 59 59	2·96	80 35	17·4	Neb susp close to ✱11
1430	J. 460	22 0 58	3·24	104 15·3	17·4	F, S, vlbM, diffic
1431	J. 461	22 1 8	3·24	104 11·2	17·4	eF, v diffic, F ✱np
1432	J. 797	22 2 59	3·04	86 59·9	17·5	vF, vS, sbM ✱14, ✱13·5 nr
1433	J. 462	22 4 38	3·22	103 27·3	17·6	F, S, Epf, bM
1434	Espin	22 5 21	2·25	37 52	17·6	Fine Cl, 6 branches, st 12–15m
1435	J. 463	22 5 41	3·34	112 47·0	17·7	F, S
1436	J. 464	22 6 27	3·19	100 53·2	17·7	eF, vS, R, vSN
1437	J. 465	22 8 37	3·06	88 37·8	17·8	pB, vS, R, mbM
1438	J. 466	22 8 45	3·32	112 7·3	17·8	F, biN
1439	J. 467	22 8 56	3·32	112 10·9	17·8	vF, S, vlbM
1440	J. 468	22 8 58	3·26	106 42·5	17·8	F, S, stellar
1441	B. 233	22 9 10	2·61	53 24	17·8	eF, S, S stellar N
1442	Espin	22 11 11	2·26	36 39	17·9	Cl of neb stars
1443	J. 469	22 11 20	3·31	111 38·3	17·9	pB, S, iF, mbM,
1444	J. 470	22 15 21	3·03	85 33·9	18·0	F, S, iF, mbM, vF ✱ close
1445	O. St.	22 17 56	3·25	107 57·5	18·1	pF, vS, gbMN
1446	J. 471	22 21 54	3·09	91 54·9	18·3	vF, stellar
1447	Sw. X.	22 22 56	3·13	95 51·6	18·3	eeF, pS, R, ✱9·0 n 3′
1448	J. 472	22 27 6	3·20	103 39·3	18·5	vF, vS, diffic
1449	J. 473	22 27 46	3·16	99 29·9	18·5	F, S, iF, bM, r
1450	B. 234	22 31 34	2·73	56 11	18·6	vF, eS, stellar
1451	J. 474	22 38 45	3·16	101 6·3	18·8	vF, S, dif, vS, excent N
1452	B. 235	22 39 2	2·94	73 53	18·8	vF, vS, quite stellar
1453	J. 475	22 39 29	3·19	104 10·9	18·8	pB, pL, R
1454	Denning	22 41 13	0·57	10 18	18·9	vF, S, ✱7 m 4′ f
1455	Spitaler 31, Burnham	22 46 37	+3·07	89 22·2	−19·1	F, pS, R, 2 st 11 nr

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1456	J. 476	22 47 56	+3·17	103 28·1	−19·1	vF, vS
1457	B. 236	22 48 8	3·12	96 18	19·1	eF, ✱10 sf 1′
1458	J. 477	22 49 24	3·13	98 7·4	19·1	vF, pL, dif
1459	Barnard	22 49 30	3·37	127 10·5	19·1	F, pS, com, N = 12m
1460	J. 478	22 49 55	3·04	86 4·2	19·2	pB, vS, mbM
1461	Sw. IX.	22 51 26	2·97	75 44·0	19·2	eeF, vS, R
1462	B. 237	22 51 34	3·02	82 21	19·2	vF, eS, ? only a ✱
1463	Engelhardt	22 52 0	3·15	101 17·0	19·2	Neb ✱ 14m
1464	J. 479	22 55 55	3·13	99 44·7	19·3	F, r, D?
1465	B. 238	22 55 59	2·96	74 10	19·3	vF, ? vS Cl
1466	J. 480	22 56 27	3·09	93 31·5	19·3	pB, vS, iF
1467	J. 481	22 57 37	3·10	93 58·9	19·4	F, S, biN
1468	J. 482	22 57 55	3·10	93 57·4	19·4	vF, vS, iF, sbM
1469	J. 483	22 59 6	3·16	104 17·4	19·4	F, S, R, F✱f
1470	{Spitaler 62, Barnard 3110}	22 59 21	2·48	30 30·5	19·4	vF, vS, stellar N north edge
1471	J. 484	23 1 24	3·15	103 24·0	19·4	pB, S, R, bM
1472	Spitaler 32	23 2 10	2·97	73 31	19·4	F, vS, bM, 2 st f
1473	Sf. 58	23 4 26	2·90	61 8·0	19·5	F, pS, gbM
1474	Spitaler 33	23 5 45	3·05	84 57·3	19·5	F, R, pS, gbM
1475	Barnard	23 6 30	3·24	119 11	19·5	Neb ✱
1476	Sf. 59	23 8 28	2·90	60 13·1	19·6	S Cl?
1477	J. 485	23 9 58	3·11	97 40·6	19·6	F, S, r
1478	B. 239	23 11 10	3·02	80 27	19·6	vF, S, dif
1479	J. 486	23 11 30	3·13	101 9·6	19·6	pF, S, R, stellar
1480	B. 240	23 11 56	3·02	79 26	19·6	vS Cl, nebs?
1481	Spitaler 34	23 12 18	3·05	84 51·7	19·6	vF, vS, R
1482	J. 487	23 13 40	3·07	89 1·9	19·7	pB, vS, R
1483	J. 798	23 15 29	3·02	79 26·3	19·7	F, S, lbM
1484	J. 799	23 15 36	3·02	79 23·0	19·7	vF, vS
1485	J. 800	23 15 44	3·03	79 23·7	19·7	vF, vS, R, vSN
1486	B. 241	23 16 49	3·04	81 7	19·7	vF, S
1487	Sw. IX.	23 17 35	3·01	76 7·7	19·7	eeF, pS, iR, ✱8 f, F✱nf
1488	J. 801	23 17 49	3·01	75 26·6	19·7	eF, vS, Ens, v diffic, h 2237s
1489	J. 488	23 19 14	3·13	103 17·0	19·8	F, vS, R, ✱9 south
1490	Sw. X.	23 21 50	3·09	94 54·2	19·8	eF, pS, R, vF✱close n
1491	J. 489	23 22 5	3·14	107 5·1	19·8	F, S, R
1492	Sw. X.	23 23 23	3·09	93 48·4	19·8	eF, S, R, sp of 2
1493	J. 802	23 23 27	3·02	76 19·1	19·8	F, vS, sbM, another susp 7s p, 1′n
1494	J. 490	23 23 30	3·12	103 29·8	19·8	F, R, lbM
1495	J. 491	23 23 31	3·13	104 15·4	19·8	F, S, lbM
1496	Sw. X.	23 23 32	+3·09	93 42·9	−19·8	eeF, pS, R, nf of 2

No.	Observer.	R.A. 1860.	Prec. 1880.	N.P.D. 1860.	Prec. 1880.	Description.
		h m s	s	° ′	″	
1497	B. 242	23 24 20	+3·03	78 29	−19·8	eF, suspected
1498	Sw. X.	23 24 39	3·09	95 46·2	19·8	eeF, pS, R, ✱9·5 p 36ˢ, 3′ s
1499	J. 492	23 24 41	3·12	104 12·9	19·8	pB, pL, iF
1500	J. 493	23 26 3	3·05	85 12·8	19·8	F, vS, Ens, lbM
1501	J. 494	23 27 29	3·08	93 55·7	19·9	vF, S, dif
1502	Sw. X.	23 30 32	2·45	15 7·2	19·9	vF, S, vF ✱ close
1503	J. 495	23 31 18	3·06	85 58·1	19·9	F, S, R, gbM
1504	J. 496	23 34 10	3·06	86 43·6	19·9	F, pL, Epf, gbM
1505	Sw. X.	23 34 12	3·08	94 20·3	19·9	eeF, pS, R, 3 st f, diffic
1506	J. 497	23 37 39	3·06	86 1·8	20·0	vF, gbM
1507	J. 498	23 38 23	3·07	89 5·6	20·0	pB, iF, mbM
1508	J. 803	23 38 48	3·05	78 44·0	20·0	F, pL, E ns
1509	J. 499	23 40 2	3·10	106 5·3	20·0	F, S, E ns, gbM
1510	J. 500	23 43 22	3·07	88 42·0	20·0	F, S, R, biN
1511	B. 243	23 43 55	3·03	63 42	20·0	eF, susp close to ✱ 12·5
1512	B. 244	23 43 56	3·03	63 44	20·0	✱ 13, nebulous?
1513	J. 804	23 46 20	3·09	79 27·9	20·0	F, vS, E pf, gbM
1514	Palisa (3235)	23 47 4	3·09	104 22	20·0	vF, S, excent N
1515	Sw. X.	23 48 51	3·07	91 46·0	20·0	eeF, pS, ✱9·5 inv. bet 2 st
1516	Sw. X.	23 48 53	3·07	91 41·3	20·0	vF, pS, R, B ✱ sf, nf of 2
1517	Sw. X.	23 49 6	3·07	91 5·2	20·0	eeF, vS, R, 3 st p
1518	J. 805	23 49 57	3·08	78 18·5	20·0	vF, vS, R
1519	J. 806	23 49 59	3·08	78 19·0	20·0	F, vS, lbM, stellar
1520	J. 501	23 50 43	3·09	104 49·1	20·0	vF, pL, R
1521	J. 502	23 51 51	3·08	97 55·7	20·0	vF, S, iF
1522	J. 503	23 51 53	3·07	89 4·3	20·0	F, S, Ens
1523	Burnham	23 51 57	3·07	83 54·6	20·0	vF, ✱4m 3′ f
1524	Sf. 87	23 52 20	3·08	94 56·0	20·0	No description
1525	Sw. IX.	23 52 54	3·04	43 54·2	20·0	eF, pS
1526	J. 807	23 54 24	3·08	79 25·9	20·0	F, S, bMSN
1527	J. 504	23 55 12	3·07	86 39·9	20·1	F, R, r, vF ✱ sf
1528	Sf. 88	23 57 54	3·07	93 53·8	20·1	No description
1529	J. 505	23 58 2	+3·07	102 17·2	−20·1	F, S, R, biN, r

Notes and Corrections to the New General Catalogue.

N.G.C.

106 R.A. is $0^h\ 17^m\ 35^s$ (O. ST.).

153 is identical with 151 (SPITALER, *A.N.* 3100).

239 R.A. is $0^h\ 38^m\ 40^s$ (O. ST.).

607 This star is not nebulous, but has a ✶ 14^m close south, looking at first sight like a nebulous appendage (SPITALER, compare *Lick Obs.* II. p. 169, and *Armagh Micr. Obs.* p. 546).

618, 627 h 136 and 141. Not observed by h in the same sweep as h 134–135. Should be struck out. Neither of them seen by BURNHAM.

737 Only a faint star (BURNHAM).

817 Seconds of R.A. should be 44 (BIGOURDAN).

846–47 are identical (SPITALER, *A.N.* 2992).

869 In last column insert †, and on p. 228, first two columns, for 521–212 read 512–207. The cluster h 212 was mapped by VOGEL (1878), PIHL (1891), and BALL and RAMBAUT (*Trans. R.I.A.* vol. xxx.).

874 No nebulosity seen by BURNHAM. For M. II. read Mu. II.

878 R.A. is $2^h\ 11^m\ 30^s$ F globular (BURNHAM).

905 An eF patch of nebulosity seen by BURNHAM in or near the place.

942 $2^h\ 22^m\ 23^s{\cdot}5$ $101^\circ\ 28'{\cdot}1$ } D neb, F Nuclei (BURNHAM).
943 $2^h\ 22^m\ 22^s{\cdot}7$ $101^\circ\ 27'{\cdot}6$ }

948 $2^h\ 21^m\ 47^s$ $101^\circ\ 10'{\cdot}1$ (BURNHAM).

955 Variability extremely doubtful. Compare *Armagh Micr. Obs.* p. 546, and *Lick Ob.* II. p. 172.

988 No nebulosity seen by BURNHAM and BARNARD. STEPHAN's position is wrong, being taken from BAILY's Lalande, where the places of two stars ($\Delta\alpha = 18^s$) are mixed up. I took the nf star, as I was not certain that it was not nebulous, while the sp one was certainly free from haze.

992 Seconds of R.A. should be 16^s (BIGOURDAN).

1059 Not found by BURNHAM, who has a vF neb 68^s p and 12′ s.

1098 $2^h\ 38^m\ 23^s$ $108^\circ\ 13'{\cdot}7$ }
1099 $2^h\ 38^m\ 48^s$ $108^\circ\ 18'{\cdot}1$ } (O. ST.)
1100 $2^h\ 39^m\ 6^s$ $108^\circ\ 16'{\cdot}9$ }

1174 Probably identical with h 281 = IV. 43 (SPITALER, *A.N.* 3030). The words "p B ✶ close f" were inserted in accordance with a correction made by Mr. SWIFT in a letter. This fourth list has "close p," which is correct.

1186 Suspected of variability by BIGOURDAN (*C.R.* 1891, No. 9). Drawing by SPITALER.

1391 $3^h\ 32^m\ 34^s$ $108^\circ\ 45'{\cdot}0$ } (O. ST.)
1394 $3^h\ 32^m\ 48^s$ $108^\circ\ 45'{\cdot}0$ }

1397 is *not* = h 305, which latter was observed by SWIFT and BURNHAM in h's place ($3^h\ 34^m\ 34^s$, $95^\circ\ 7'{\cdot}0$). Compare *Monthly Notices*, lii. p. 102.

1458 Not found by BURNHAM.

1499 is about half a degree in length. See a drawing by SCHEINER in *A.N.* 3157.

1554 HIND's variable nebula, 2^s p and 40″ south of the variable star T *Tauri*. BARNARD in 1890 found an e F neb in Pos. 185°, dist ¾′ from T, which agrees well with HIND's and D'ARREST's observations. BARNARD and BURNHAM also saw T *Tauri* within a very small condensed nebula (often seen by TEMPEL). BIGOURDAN's No. 144 (✶ 13 nebulous?) in $4^h\ 13^m\ 56^s$, $70^\circ\ 52'$, was apparently not seen at the Lick Observatory.

1640 R.A. $4^h\ 36^m\ 10^s$ } (O. ST.).
1710 R.A. $4^h\ 50^m\ 56^s$ }

1725 Seconds of R.A. should be 46 (BURNHAM).

1728 R.A. is $4^h\ 52^m\ 51^s$ (BURNHAM).

1757 Not seen by SPITALER.

2237, 2238 are parts of an e L nebulous ring surrounding the cluster h 392. See a sketch by BARNARD, *A.N.* 2918.

2287 For M. 14 read M. 41.

N.G.C.

2330
2334 Not seen by Kobold (with the 18-inch refractor at Strassburg), who observed eleven nebulæ about this place.

2361 This is probably = V. 21, for which H gave the R.A. $7^h\ 12^m\ 2^s$. d'Arrest's R.A. agrees with Bigourdan's.

2433 h's R.A. is correct (Spitaler).

2452 Not planetary, but bi-nuclear (Burnham).

2459 No nebulosity, only a couple of F stars seen by Spitaler.

2543 R.A. is $8^h\ 3^m\ 46^s$ (Spitaler).

2618 R.A. is $8^h\ 29^m\ 1^s$ (Bigourdan).

2652 Not found by Spitaler.

2846 Bigourdan's No. 153: $9^h\ 13^m\ 15^s$, 104° 6′, v F, stellar, is doubtless = 2846.

2871
2875 Not seen by Spitaler; but he is wrong in assuming them = h 597 and 598. They are marked ϵ and γ in the Birr diagram.

3234 is not = 3235; both seen by Denning.

3328 $10^h\ 32^m\ 19^s$, 80° 3′·4, v S Cl, not nebulous (Spitaler).

3331 R.A. $10^h\ 32^m\ 18^s$
3335 R.A. $10^h\ 32^m\ 54^s$ (O. St.).

3531 to be struck out, is = 3526 (Spitaler).

3666 Later observations at Armagh in 1889 and 1891 have not confirmed the suspected variability.

3679 The position should be $11^h\ 19^m\ 2^s$, 94° 48′·8, according to Spitaler, who found nothing in Auwers' place, as well as in that given in the Catalogue.

3745
3746
3748
3750
3751
3753
3754 The R.A.'s of these should be increased by $1^m\ 32^s$, and the N.P.D. diminished by 15′·9, as pointed out by Kobold in the *A.N.* 3241. In the Birr diagram the objects α and ι should be removed from the diagram (their places in the *N.G.C.* are correct). The error was caused by my assuming two stars described on different nights as "very red" and "reddish" to be identical, which they are not (see *A.N.* 3246).

3760 delenda. It is = 3301 with an error of 1^h in R.A. Nothing seen in d'Arrest's place at Birr Castle and Strassburg.

3813 Pos. of elongation 83° (Armagh). Also observed and drawn by Spitaler.

3855 R.A. is $11^h\ 36^m\ 56^s$, while d'A.'s P.D. is correct (Spitaler).

3856 $11^h\ 37^m\ 6^s$, 55° 53′·3, v F, R, b M (Spitaler).

3871 $11^h\ 38^m\ 52^s$, 56° 8′·0 (Spitaler). In "Description" *dele* (?). To the note on p. 218 should be added that Spitaler has seen them all four. The Catalogue places of the three following ones are correct.

3876 Seconds of R.A. should be 14^s (Spitaler).

3930 The star is *Groombridge* 1830, the large P.M. of which is illustrated by the change of relative position of nebula and star.

4013 Pos. of E 60° to 70° (Armagh, 1891). No change.

4042 Not seen by Spitaler.

4107 Dele o; the star is np (Burnham).

4170 = Bigourdan 169, $12^h\ 5^m\ 11^s$, 60° 1′.

4208 Not seen by Spitaler, to be struck out.

4572 R.A. is $12^h\ 30^m\ 30^s$ (Bigourdan), which agrees better with H ($30^m\ 18^s$) than with h.

4731 H in 1784 described it as "lb M," not "sb M," as in *G.C.* There has apparently not been any change; it is diffused, without condensation. The R.A. in *N.G.C.* (h) is correct (Armagh, 2 obs.).

4849 $12^h\ 51^m\ 24^s$, 62° 52′ (Spitaler).

5510 $14^h\ 5^m\ 55^s$
5664 $14^h\ 27^m\ 5^s$
5726 $14^h\ 35^m\ 7^s$ (O. St.).
5741 $14^h\ 38^m\ 17^s$
5742 $14^h\ 38^m\ 2^s$

5824 is = h 1900 (Barnard, *A.N.* 2995). It also occurs in the Cordoba D.M.

N.G.C.

5834 to be struck out, is = 5824.

5856 No nebulosity seen by BIGOURDAN.

5863 $15^h\ 2^m\ 53^s$, 107° 58′, BIGOURDAN.

5872 Description is: v F, S, R, v mb M, * 13 nf ½′ (BIGOURDAN).

5881 Not found by BIGOURDAN.

5883 Description is: v F, p S, stellar N (BIGOURDAN).

5884 No nebulosity; only two F stars seen by BIGOURDAN.

5891 Place is $15^h\ 8^m\ 35^s$, 100° 58′·5 (BIGOURDAN).

5926 Not found by BIGOURDAN.

5928 This is possibly *Messier* 102, found by MÉCHAIN: "Nébuleuse entre les étoiles *o* du *Bouvier* et *ι* du *Dragon*: elle est très foible; près d'elle est une étoile de la sixième grandeur." I assume that *ι Draconis* is an error for *ι Serpentis*.

5941, 5942 } These are situated sp and nf, according to BIGOURDAN.

6015 D'ARREST's description is correct (DENNING).

6059 Seconds of R.A. should be 56^s (BIGOURDAN).

6065, 6066 } Occur also in SWIFT's list IX., where the P.D.'s seem to have been interchanged, though the objects are still said to be sp, nf.

6111 In SWIFT's list IX. the declination for 1890 is given as 63° 32′·6. It was 62° in the MS. communication sent me in 1887.

6194 BIGOURDAN 209 assumed identical with this, as the places and descriptions agree perfectly.

6302 seems to be *Dunlop* No. 567.

6393 SWIFT IX. 81 assumed identical with this.

6557 N.P.D. is 166°, not 116°.

6589 Place is $18^h\ 8^m\ 35^s$, 109° 48′·9, and 6590 is = 6595 (BARNARD, *A.N.* 3101).

6660 is = 6661 (PECHÜLE, *A.N.* 3259).

6924 R.A. $20^h\ 24^m\ 57^s$ } (O. St.).
6936 R.A. $20^h\ 26^m\ 26^s$ }

6951 is = 6952 (DENNING).

7001 is pB, according to SPITALER.

7030 Min. of R.A. is 3 (O. St.).

7045 is not a nebula, but only a couple of vF stars close together (SPITALER).

7074 N.P.D. is 83° 55′·5 (SPITALER).

7100 Seconds of R.A. are 41^s, P.D. 81° 45′·2 (SPITALER).

7101 Not seen by SPITALER; evidently = 7100.

7103, 7104 } R.A. $31^m\ 55^s$ and $32^m\ 6^s$ (O. St.).

7132 Seconds of R.A. should be 25^s (SPITALER).

7157 Not found by SPITALER.

7170 R.A. $21^h\ 55^m\ 7^s$ }
7341 R.A. $22^h\ 31^m\ 27^s$ } (O. St.).
7359 R.A. $22^h\ 38^m\ 1^s$ }

7403 Occurs only in one Harvard Zone (156). SPITALER and BURNHAM have not seen any nebulosity. The small nebula found by them 40^s f, 7′ south can, of course, not have been the object observed in the zone.

7447 to be struck out, as BURNHAN also could not find it. He only saw a F triple star a little np the place.

7472, 7477 } to be struck out, both being = 7482 with errors of 2^m and 1^m in R.A. (BURNHAM).

7793 Occurs in the Cordoba D.M., $23^h\ 50^m\ 38^s$, 123° 22′·3.

7804 to be struck out, only a F double star without nebulosity (BURNHAM).

7821 R.A. $23^h\ 58^m\ 7^s$ (O. St.).

Note to page 223, *cluster VI.* 8 (*G.C.* 3967).

I have examined the observation of this object in Caroline Herschel's copy of the sweeps in the Society's library. VI. 8 was observed on April 25, 1784, on which night three sweeps (207–209) were observed, often interrupted by clouds (the date given in *P.T.* 1786 is therefore *not* wrong). It is the only object in sweep 209, and is thus described: "A very close compressed cluster of stars 8′ or 9′ in diam., extremely rich, of an i R figure, a little E. The stars are so small as hardly to be visible, and so accumulated in the middle as to look nebulous. Mayer's 577 Z f 1′ 48″ n 1° 26′, R.A. 14^h 30′ 5″, P.D. 98° 15′," with this footnote: "The disagreement in the zeros of the two stars leaves it very doubtful if they are Mayer's 574 and 577." The observations of the two stars are given thus:

$7{\cdot}8^m$ Mayer's 574	Z 14^h 17′ 52″·4	99° 5′ 51″
	10 36	1 19
	Cor + 17 16	Z 97 47
7^m Mayer's 577	Z 14 28 16·9	99 40 52
Cat. of O st. No. 367	10 42	1 45
	Cor + 17 35	Z 97 56

The description of the object agrees with I 70 = h 1813, but there must be some considerable error in the observation of position. The matter is in any case not of much importance, as so remarkable an object could not have been overlooked up to this, and it must therefore be identical with some known bright nebula.

Double-star Observations, 1892–94. By W. H. Maw.

[Received Feb. 21; read March 8, 1895].

The observations recorded in the present paper form a continuation of those dealt with in a previous communication published in the *Memoirs of the Royal Astronomical Society*, vol. l. page 75. The instrument used has been the same as that employed for the earlier measures, namely, a 6-in. equatorial refractor, constructed by Messrs. T. Cooke & Sons, of York. The micrometer was constructed by the same makers; and its screw has a value of $23''.51$ per revolution, or $11''.93$ when used with the Barlow lens, which was occasionally employed. The five eyepieces used have magnifying powers of 90, 130, 215, 300, and 400 respectively, and in the following record of observations they are numbered I., II., III., IV., and V. When used in combination with the Barlow lens the powers of the eyepieces are practically doubled, and in the following list their use in such combination is denoted by the addition of the letter *b* to the number of the eyepiece; thus, I. *b*, II. *b*, &c.

As in the case of the observations recorded in the previous paper, each night's measures of any pair of stars consisted, as a rule, of four measures of position-angle and three double measures of distance, these numbers of measures being, however, exceeded in many cases when the seeing was unsteady.

As in the former list, the results of the observations are tabulated in six columns, of which the first gives the epoch; the second, the position-angle; the third, the distance; the fourth, the eyepiece used; the fifth, the sidereal time at which the measures were made; and the sixth, remarks.

The positions of the stars are given for the epoch 1890 and are approximate, the R.A.'s being given to the nearest tenth of a minute of time, and the declinations to the nearest minute of arc.

The measures are as follows :—

No. 1. Σ 40. (6·8—8·8.)

R.A. $0^h\ 29^m{\cdot}5$ Decl. + 35° 13′

	°	″		h m
1892·704	314·2	11·46	II.	22 30

No. 2. Σ 60 = η *Cassiopeiæ*. (4—7·5.)

R.A. $0^h\ 42^m{\cdot}6$ Decl. + 57° 14′

	°	″		h m
1894·108	200·7	5·02	III.	7 50
1894·132	199·5	4·95	IV.	5 25
1894·135	200·3	4·90	IV.	6 5
1894·125	200·2	4·96		

No. 3. Σ 61 = 65 *Piscium*. (6—7.)

R.A. $0^h\ 43^m{\cdot}5$ Decl. + 27° 7′

	°	″		h m
1892·978	296·6	4·34	IV.	4 55

No. 4. Σ 73 = 36 *Andromedæ*. (6·3—6·3.)

R.A. $0^h\ 48^m{\cdot}9$ Decl. + 23° 2′

	°	″		h m
1892·913	11·7	1·21	V.	2 40
1892·924	10·3	1·34	IV.	2 35
1892·978	11·2	1·29	IV.	4 30
1893·094	11·9	1·25	V.	3 10
1892·977	11·4	1·27		

	°	″		h m
1893·962	11·9	1·05	V.	3 30
1894·075	12·7	1·02	V.	2 50
1894·132	12·6	1·15	IV.	4 55
1894·056	12·4	1·07		

No. 5. Σ 113 = 42 *Ceti*. (6·5—7.)

R.A. $1^h\ 14^m{\cdot}0$ Decl. − 1° 5′

	°	″		h m
1892·924	350·4	1·52	IV.	2 10
1893·094	354·5	1·46	IV.	3 35
1893·097	353·7	1·47	V.	3 10
1893·038	352 9	1·48		

No. 6. Σ 227 = ι *Trianguli*. (5·5—7.)

R.A. $2^h\ 5^m\ 6$ Decl. + 29° 47′

	°	″		h m
1893·105	75·9	3·70	III.	7 5
1893·121	74·5	3·54	IV.	6 45
1893·135	74·9	3·64	IV.	5 40
1893·120	75·1	3·63		

No. 7. Σ 229 = γ *Ceti*. (3·5—7.)

R.A. $2^h\ 37^m{\cdot}6$ Decl. + 2° 46′

	°	″		h m
1893·962	288·0	2·73	IV.	3 55
1894·045	288·0	2·69	IV.	5 25
1894·003	288·0	2·71		

No. 8. β 9. (6·3—8·4.)

R.A. $2^h\ 40^m{\cdot}2$ Decl. + 35° 6′

	°	″		h m
1893·121	162·6	1·28	V.	7 50

No. 9. Σ 305 = 114 *Arietis.* (7·3—8·2.)

R.A. 2h 41m·2, Decl. + 18° 55′

	°	″		h m
1893·105	316·4	3·31	III.	7 40
1893·121	315·8	3·07	IV.	7 15
1893·171	315·6	2·88	IV.	6 50
1893·132	315·9	3 09		

No. 10. OΣ 50. (7·5—7·5.)

R.A. 3h 1m·6, Decl. + 71° 8′

	°	″		h m
1893·190	206·2	1·28	IV.	8 40
1893·209	206·6	1·29	IV.	8 50
1893·215	205·0	1·25	V.	9 15
1893·205	205·9	1·27		

No. 11. Σ 389. (7—8.)

R.A. 3h 21m·3, Decl. + 58° 59′

	°	″		h m
1894·157	67·0	2·48	IV.	8 15
1894·165	67·0	2·55	IV.	8 50
1894·171	67·1	2·46	IV.	7 55
1894·164	67·03	2·50		

No. 12. Σ 422 = P. III. 98. (6—8.)

R.A. 3h 31m·1, Decl. + 0° 16′

	°	″		h m
1891·067	245·6	6·27	IV.	4 35
1891·956	244·6	6·30	III.	5 10
1892 001	244·5	6·17	III.	5 5
1891·675	244·9	6·25		
1893·094	244·9	6·24	III.	6 5

No. 13. Σ 425. (7·3—7·3.)

R.A. 3h 33m·1, Decl. + 33° 46′

	°	″		h m
1894·165	93·2	2·91	IV.	9 50
1894·171	92·6	3·10	III.	7 5
1894·231	92·2	3·00	III.	9 15
1894·189	92·7	3·00		

No. 14. OΣ 67. (5—8·2.)

R.A. 3h 47m·8, Decl. + 60° 47′

	°	″		h m	
1894·157	48·5	...	V.	8 45	Clouded over.
1894·165	46·8	1·75	V.	9 20	
1894·161	47·6	1·75			

No. 15. Σ 460 = 49 *Cephei.* (5·2—6.)

R.A. 3h 50m·2, Decl. + 80° 24′

	°	″		h m
1893·190	44·8	1·01	V.	9 10
1893·209	43·6	0·94	V.	9 20
1893·215	42·9	0·93	V.	9 30
1893·205	43·8	0·96		

No. 16. Σ 535 = 230 *Tauri.* (6·7—8·2.)

R.A. 4h 17m·3, Decl. + 11° 7′

	°	″		h m
1890·034	338·7	1·63	III. *b*	7 5
1893·105	329·8	1·51	V.	7 55
1893·121	330·0	1·44	IV.	8 5
1893·190	328·5	1·74	IV.	8 5
1893·139	329·4	1·56		

No. 17. OΣ 81 = 56 *Persei.* (6—8·8.)

R.A. 4h 17m·6, Decl. + 33° 42′

	°	″		h m
1894·234	44·6	4·58	III.	9 30

No. 18. Σ 572. (7—7.)

R.A. $4^h\ 31^m{\cdot}7$, Decl. + 26° 43′

	°	″		h m
1894·108	202·4	3·69	III.	8 25
1894·132	202·1	3·73	IV.	5 50
1894·149	201·7	3·64	III.	7 15
1894·130	202·1	3·69		

No. 19. Σ 749. (6·5—7.)

R.A. $5^h\ 30^m{\cdot}3$, Decl. + 26° 51′

	°	″		h m
1892·217	175·8	1·15	IV.	8 5
1892·264	181·6	1·01	IV.	10 5
1892·275	178·2	0·92	V.	9 15
1892·252	178·5	1·03		

No. 20. Σ 948 = 12 *Lyncis*. (6—6·5—7·4.)

R.A. $6^h\ 36^m{\cdot}4$, Decl. + 59° 33′

A—B

	°	″		h m
1893·209	121·8	1·52	V.	9 50
1893 215	122·2	1·47	V.	9 45
1893·217	121·3	1·44	V.	9 0
1893·214	121·8	1·48		

A—C

	°	″		h m
1893·209	306·3	8·28	V.	10 5
1893·215	306·2	8·22	V.	10 10
1893·217	306·1	8·22	V.	9 10
1893·214	306·2	8·24		

No. 21. Σ 1037. (7·1—7·1.)

R.A. $7^h\ 6^m{\cdot}0$, Decl. + 27° 25′

	°	″		h m
1893·225	306·0	1·07	V.	10 5
1893·245	307·8	1·01	V.	8 45
1893·247	306·9	1·14	IV.	9 55
1893·239	306·9	1·07		

No. 22. OΣ 170 = P. VII. 52. (7·5—7·5.)

R.A. $7^h\ 12^m{\cdot}1$, Decl. + 9° 30′

	°	″		h m
1892·217	110·1	1·58	IV.	8 30

No. 23. Σ 1081. (7·5—8·5.)

R.A. $7^h\ 17^m{\cdot}6$, Decl. + 21° 40′

	°	″		h m
1893·253	229·6	1·38	II. *b*	10 30
1894·231	230·0	1·49	IV.	10 55
1894·234	227·6	1·57	IV.	10 20
1893·906	229·1	1·48		

No. 24. Σ 1126 = P. VII. 170. (7·2—7·5.)

R.A. $7^h\ 33^m{\cdot}3$, Decl. + 5° 29′

	°	″		h m
1893·245	144·3	1·12	V.	9 15
1893·247	143·6	1·21	IV.	10 10
1893·253	142·3	—	II. *b*	9 40
1893·248	143·4	1·16		

No. 25. OΣ 182. (8·5—8·5.)

R.A. $7^h\ 47^m{\cdot}2$, Decl. + 3° 40′

	°	″		h m
1892·217	33·2	1·11	IV.	8 50
1892·261	32·7	1·03	IV.	11 5
1892·274	31·4	1·10	IV.	9 40
1892·251	32·4	1·08		

No. 26. Σ 1157. (8—8.)

R.A. $7^h\ 49^m$, Decl. − 2° 31′

	°	″		h m
1893·245	245·6	1·22	IV.	9 35
1893·247	246·8	1·10	IV.	9 40
1893·246	246·2	1·16		

No. 27. Σ 1177. (6·5—7·4.)

R.A. $7^h\ 58^m{\cdot}6$
Decl. + 27° 50′

	°	″		h m
1893·245	352·5	3·27	IV.	10 30
1893·247	351·3	3·57	IV.	10 25
1893·253	352·4	3·37	II. *b*	10 0
1893·248	352·1	3·40		

No. 28. Σ 1187 = 85 *Lyncis*. (7·1—8.)

R.A. $8^h\ 2^m{\cdot}6$
Decl. + 32° 33′

	°	″		h m	
1893·217	46·1	2·28	V.	10 15	Stars very faint.
1893·225	46·9	1·88	V.	9 45	
1893·228	47·6	1·76	IV.	9 22	Unsteady.
1893·223	46·9	1·97			

No. 29. Σ 1196 = ζ *Cancri*. (5—5·7—5·5.)

R.A. $8^h\ 5^m{\cdot}9$
Decl. + 18° 0′

A—B

	°	″		h m
1892·217	31·6	1·19	IV.	10 10
1892·261	30·4	0·98	V.	10 20
1892·264	32·7	1·12	IV.	10 20
1892·247	31·6	1·09		

	°	″		h m
1893·215	26·7	1·07	V.	10 35
1893·217	27·3	1·07	V.	9 45
1893·225	25·3	1·08	V.	9 0
1893·219	26·4	1·07		

	°	″		h m
1894·231	23·9	1·00	V.	9 50
1894·234	25·0	1·07	IV.	10 40
1894·251	24·8	1·13	IV.	11 35
1894·272	26·2	0·99	V.	11 15
1894·247	25·0	1·05		

A—C

	°	″		h m
1892·217	116·7	5·13	IV.	10 15
1892·261	117·3	5·37	V.	10 35
1892·264	116·4	5·41	IV.	10 35
1892·247	116·8	5·30		

	°	″		h m
1893·215	116·0	5·27	V.	10 50
1893·217	116·4	5·04	V.	9 55
1893·225	116·0	5·00	V.	9 10
1893·219	116·1	5·10		

	°	″		h m
1894·231	115·3	5·09	IV.	10 15
1894·234	117·3	4·97	IV.	10 55
1894·251	115·3	5·01	IV.	11 45
1894·272	115·9	4·85	V.	11 30
1894·247	115·9	4·98		

No. 30. Σ 1282. (7—7.)

R.A. $8^h\ 43^m{\cdot}7$
Decl. + 35° 27′

	°	″		h m
1893·351	276·6	3·75	III.	12 30
1893·371	277·6	3·67	III.	14 30
1893·361	277·1	3·71		

No. 31. Σ 1280. (7·5—7·6.)

R.A. $8^h\ 45^m{\cdot}4$
Decl. + 71° 14′

	°	″		h m
1893·335	43·7	5·49	III.	12 30
1893·343	43·3	5·38	III.	12 30
1893·349	43·4	5·35	III.	12 45
1893·342	43·5	5·41		

No. 32. Σ 1289. (7·7—8·5.)

R.A. $8^h\ 47^m{\cdot}6$
Decl. + 44° 0′

	°	″		h m
1894·302	5·9	4·49	III.	12 20
1894·376	5·1	4·15	III.	13 15
1894·339	5·5	4·32		

No. 33. Σ 1333. (6·6—6·9.)

R.A. 9h 11m·7, Decl. + 35° 50′

	°	″		h m	
1892·321	46·5	—	IV.	13 10	Clouded over.
1892·327	44·6	1·73	IV.	13 20	
1892·330	44·4	1·77	IV.	12 10	
1892·354	45·9	1·59	IV.	13 30	
1892·333	45·3	1·70			

No. 34. OΣ 199 = 37 *Lyncis*. (6·1—10·2.)

R.A. 9h 12m·7, Decl. + 51° 46′

	°	′		h m
1893·343	119·7	5·38	III.	12 55

No. 35. Σ 1338 = 157 *Lyncis*. (7—7·2.)

R.A. 9h 13m·8, Decl. + 38° 39′

	°	″		h m
1892·272	164·0	1·66	IV.	12 10
1892·275	163·7	1·50	IV.	11 30
1892·308	160·3	1·47	IV.	13 10
1892·285	162·7	1·54		

No. 36. OΣ 201. (7·5—9.)

R.A. 9h 17m·2, Decl. + 28° 24′

	°	″		h m	
1892·275	225·7	1·29	IV.	10 5	
1892·327	224·1	—	IV.	13 5	Clouded over.
1892·351	226·2	1·33	IV.	13 55	
1892·318	225·3	1·31			

No. 37. Σ 1348 = 116 (B) *Hydræ*. (7·5—7·6.)

R.A. 9h 18m·5, Decl. + 6° 47′

	°	″		h m	
1892·299	324·9	1·55	IV.	11 30	
1892·308	324·0	1·59	IV.	12 20	
1892·321	326·5	1·50	IV.	12 30	Bad seeing.
1892·309	325·1	1·55			

No. 38. Σ 1355. (7·2—7·2.)

R.A. 9h 21m·5, Decl. + 6° 47′

	°	″		h m
1892·299	336·4	2·81	IV.	12 0
1892·308	331·5	2·57	IV.	12 45
1892·321	331·9	2·75	IV.	12 50
1892·309	333·2	2·71		

No. 39. Σ 1356 = ω *Leonis*. (5·5—7·)

R.A. 9h 22m 6, Decl. + 9° 31′

	°	″		h m
1892·217	100·4	0·79	V.	10 30
1892·261	100·9	0·73	V.	11 25
1892·272	105·8	0·79	V.	10 55
1892·250	102·4	0·77		

No. 40. Σ 1417. (8·5—8·5.)

R.A. 10h 9m, Decl. + 19° 42′

	°	″		h m
1892·272	78·5	2·49	IV.	11 30
1892·275	77·6	2·54	IV.	11 45
1892·308	76·9	2·65	IV.	11 40
1892·285	77·7	2·56		

No. 41. OΣ 229. (6·7—7·1.)

R.A. 10h 43m·7, Decl. + 41° 41′

	°	″		h m
1892·357	325·1	0·83	V.	14 10
1892·480	321·7	0·84	V.	16 25
1892·486	322·0	0·82	IV.	16 25
1892·441	322·9	0·83		

No. 42. Σ 1500. (7·6—8.)

R.A. 10h 53m·4, Decl. — 2° 48′

	°	″		h m
1893·247	312·8	1·41	IV.	11 20
1893·253	311·8	1·28	II. *b*	10 50
1893·286	312·6	1·15	IV.	12 25
1893·262	312·4	1·28		

No. 43. Σ 1523 = ξ *Ursæ Majoris.* (4—4·5.)

R.A. $11^h\ 12^m·3$
Decl. + 32° 9′

	°	″		h m
1892·299	197·8	1·61	IV.	12 40
1892·308	196·4	1·80	IV.	13 30
1892·327	197·1	1·85	IV.	13 50
1892·357	196·3	1·73	IV.	13 35
1892·323	196·9	1·75		

	°	″		h m
1893·286	187·8	1·82	IV.	12 55
1893·335	187·4	1·82	IV.	13 10
1893·343	187·6	1·63	V.	13 35
1893·371	186·5	1·61	V.	15 5
1893·334	187·3	1·72		

	°	″		h m
1894·302	183·9	1·87	IV.	13 5
1894·376	182·7	1·90	IV.	13 55
1894·384	182·5	1·83	IV.	15 40
1894·354	183·0	1·87		

No. 44. Σ 1543. (5·2—8·2.)

R.A. $11^h\ 23^m·1$
Decl. + 39° 57′

	°	″		h m
1892·387	4·2	5·06	III.	14 50
1892·409	4·6	5·44	III.	15 10
1892·434	4·8	5·26	III.	16 45
1892·410	4·5	5·25		

No. 45. Σ 1606. (6·3—7.)

R.A. $12^h\ 5^m·2$
Decl. + 40° 31′

	°	″		h m
1892·486	332·9	1·19	IV.	16 55
1892·488	334·3	1·08	V.	16 35
1892·499	333·0	1·15	IV.	16 45
1892·491	333·4	1·14		

No. 46. Σ 1647 = 191 (B) *Virginis.* (7·5—7·6).

R.A. $12^h\ 25^m$
Decl. + 10° 20′

	°	″		h m
1892·390	220·8	1·46	IV.	13 0
1892·436	222·0	1·54	II. *b*	15 30
1892·480	221·8	1·43	IV.	15 55
1892·435	221·5	1·48		

No. 47. Σ 1669. (6—6·5.)

R.A. $12^h\ 35^m·5$
Decl. − 12° 18′

	°	″		h m
1893·253	303·5	5·76	II. *b*	11 25
1893·264	305·6	5·76	III.	11 40
1893·277	305·7	5·27	III.	11 10
1893·265	304·9	5·60		

No. 48. Σ 1687 = 35 *Comæ Berenices.* (5—8.)

R.A. $12^h\ 47^m·9$
Decl. + 21° 51′

	°	″		h m
1892·357	73·4	1·30	V.	15 0
1892·436	70·7	1·26	II. *b*	15 50
1892·480	72·1	1·14	V.	17 10
1892·424	72·1	1·23		

No. 49. OΣ 266. (7·3—7·8.)

R.A. $13^h\ 23^m·1$
Decl. + 16° 18′

	°	″		h m
1892·488	337·2	1·59	V.	17 30
1892·499	341·8	1·76	IV.	16 25
1892·504	340·7	1·81	V.	17 35
1892·497	339·9	1·72		

No. 50. Σ 1752 = P. XIII. 127. (7·8—8·9.)

R.A. $13\ 28^{m}{\cdot}9$
Decl. + 0° 15′

	°	″		h m
1893·458	75·2	2·45	IV.	15 30
1893·461	75·5	2·54	IV.	16 0
1893·460	75·3	2·50		

No. 51. Σ 1772. (6·2—9·1.)

R.A. $13^{h}\ 35^{m}{\cdot}4$
Decl. + 20° 30′

	°	″		h m	
1893·455	141·1	4·25	IV.	16 30	
1893·458	140·3	—	IV.	16 40	Bad seeing.
1893·461	140·8	4·35	IV.	16 15	
1893·458	140·7	4·30			

No. 52. Σ 1777 = 84 *Virginis.* (5·8—8·2.)

R.A. $13^{h}\ 37^{m}{\cdot}5$
Decl. + 4° 6′

	°	″		h m
1892·387	231·2	3·56	III.	14 10
1892·406	229·4	3·40	III.	15 40
1892·409	231·0	3·49	III.	14 45
1892·401	230·5	3·48		

No. 53. Σ 1781. (7·8—8·2.)

R.A. $13^{h}\ 40^{m}{\cdot}7$
Decl. + 5° 40′

	°	″		h m
1893·401	269·8	1·10	IV.	14 45
1893·455	269·7	1·03	IV.	16 0
1893·428	269·75	1·06		

No. 54. Σ 1785. (7·2—7·5.)

R.A. $13^{h}\ 44^{m}{\cdot}2$
Decl. + 27° 27′

	°	″		h m
1892·436	248·4	—	II. *b*	16 40
1892·486	249·1	1·73	IV.	17 15
1892·488	250·0	1·58	V.	17 55
1892·507	248·8	1·81	IV.	16 40
1892·479	249·1	1·71		

No. 55. Σ 1813. (8—8·1.)

R.A. $14^{h}\ 7^{m}{\cdot}9$
Decl. + 5° 55′

	°	″		h m
1894·376	193·0	4·82	III.	14 35
1894·384	194·1	4·84	IV.	15 25
1894·499	192·5	4·89	III.	17 25
1894·420	193·2	4·85		

No. 56. OΣ 279. (6·8—9.)

R.A. $14^{h}\ 8^{m}{\cdot}5$
Decl. + 12° 31′

	°	″		h m	
1892·507	253·9	2·10	IV.	17 35	
1892·551	253·4	—	IV.	17 25	Stars faint.
1892·595	253·8	2·24	IV.	18 40	
1892·598	252·1	2·17	IV.	18 40	
1892·563	253·3	2·17			

No. 57. Σ 1820. (8·2—8·5.)

R.A. $14^{h}\ 9^{m}{\cdot}5$
Decl. + 55° 50′

	°	″		h m	
1894·524	75·9	2·26	IV.	17 30	
1894·529	74·3	2·31	IV.	17 50	
1894·532	73·0	—	IV.	18 25	Clouded over.
1894·568	73·7	2·31	IV.	18 40	
1894·438	74·2	2·29			

No. 58. Σ 1819. (7·9—8.)

R.A. $14^{h}\ 9^{m}{\cdot}8$
Decl. + 3° 29′

	°	″		h m
1894·376	185·3	1·47	IV.	14 20
1894·384	184·7	1·27	IV.	14 55
1894·505	186·2	1·40	IV.	17 30
1894·422	185·4	1·38		

No. 59. Σ 1816 (7—7·1.)

R.A. $14^{h}\ 9^{m}{\cdot}9$
Decl. + 29° 37′

	°	″		h m
1894·505	81·5	1·50	IV.	17 55
1894·524	82·7	1·43	IV.	16 55
1894·529	82·0	1·52	IV.	17 0
1894·519	82·1	1·48		

No. 60. Σ 1825. (6·8—8·5.)

R.A. 14h 11m·2, Decl. + 20° 38′

	°	″		h m
1893·455	173·2	3·94	IV.	16 50
1893·458	174·5	4·01	IV.	17 10
1893·461	173·3	3·98	IV.	16 45
1893·458	173·7	3·98		

No. 61. Σ 1830. (8·5—9·8.)

R.A. 14h 12m·2, Decl. + 57° 11′

	°	″		h m
1893·685	289·8	6·03	III.	20 30
1893·726	288·5	6·14	III.	21 10
1893·768	287·0	6·08	III.	21 50
1893·726	288·4	6·08		

No. 62. Σ 1831. (6—9.)

R.A. 14h 12m·7, Decl. + 57° 13′

	°	″		h m
1893·601	139·4	5·42	III.	19 50
1893·724	139·8	5·83	III.	21 40
1893·768	139·5	5·52	III.	22 30
1893·698	139·6	5·59		

No. 63. Σ 1867. (7·8—8·2.)

R.A. 14h 36m, Decl. + 31° 46′

	°	″		h m
1894·568	17·6	1·38	IV.	19 45
1894·620	16·3	1·06	IV.	19 10
1894·639	16·6	1·14	IV.	19 45
1894·609	16·8	1·19		

No. 64. Σ 1871. (7—7.)

R.A. 14h 37m·8, Decl. + 51° 52′

	°	″		h m
1894·568	292·6	1·72	IV.	20 5
1894·620	290·3	1·60	IV.	19 25
1894 639	291 2	1 69	IV.	20 10
1894 609	291 4	1·67		

No. 65. Σ 1884. (6·2—7·8.)

R.A. 14h 43m·4, Decl. + 24° 49′

	°	″		h m
1892·579	56·8	1·36	IV.	19 10
1892·595	55·6	1·67	IV.	19 20
1892·598	55·4	1·88	IV.	19 10
1892·591	55·9	1·64		

No. 66. Σ 1888 = ξ *Bootis*. (4·7—6·6.)

R.A. 14h 46m·3, Decl. + 19° 33′

	°	″		h m
1892·406	239·4	3·10	III.	15 20
1892·409	239·2	3·19	III.	15 40
1892·428	239·5	3·05	IV.	16 30
1892·414	239·4	3·11		
1893·464	235·9	2·99	V.	17 0
1893·467	236·2	2·88	V.	15 40
1893·470	235·4	3·01	IV.	17 20
1893·467	235·8	2·96		
1894·524	231·2	2·91	IV.	18 5
1894·529	230·9	2·72	IV.	17 25
1894·532	231·5	3·08	IV.	17 50
1894·528	231·2	2·90		

No. 67. Σ 1937 = η *Coronæ Borealis*. (5·2—5·7.)

R.A. 15h 18m·6, Decl. + 30° 41′

	°	″		h m
1893·478	244·7	0·63	V.	18 10

No. 68. Σ 1938 = μ^2 *Bootis*. (6·7—7·3.)

R.A. 15h 20m·3, Decl. + 37° 46′

	°	″		h m
1893·478	87·4	0·79	V.	17 50
1893·508	89·8	0·76	V.	18 25
1893·493	88·6	0·77		

No. 69. Σ 1972 = π^1 *Ursæ Minoris.* (6·1—7.)

R.A. $15^h\ 35^m{\cdot}5$
Decl. + 80° 49′

				h m
1892·773	80°·0	30″·21	II.	22 25

No. 70. Σ 1984. (6·2—8·5.)

R.A. $15^h\ 48^m{\cdot}4$
Decl. + 53° 14′

				h m
1892·773	274°·7	6″·03	II.	22 5
1892·795	272·2	6·72	III.	23 20
1892·797	273·4	6·12	III.	22 55
1892·788	273·4	6·29		

No. 71. Σ 1985. (7—8·1.)

R.A. $15^h\ 50^m{\cdot}2$
Decl. − 1° 51′

				h m
1893·464	336°·7	5″·70	III.	15 50
1893·467	335·2	5·59	IV.	16 10
1893·469	336·6	5·35	III.	16 50
1893·467	336·2	5·55		

No. 72. Σ 1998 = ξ *Scorpii.* (5—5·5.)

R.A. $15^h\ 57^m{\cdot}7$
Decl. − 11° 4′

				h m
1892·507	206°·4	1″·27	IV.	17 5
1892·538	210·8	1·18	IV.	17 10
1892·551	206·9	1·23	IV.	16 50
1892·532	208·0	1·23		

No. 73. Σ 2021 = 49 *Serpentis.* (6·7—6·9.)

R.A. $16^h\ 8^m{\cdot}1$
Decl. + 13° 49′

				h m
1893·601	331°·8	3″·98	III.	18 55

No. 74. Σ 2032 = σ *Coronæ Borealis.* (6—6·5.)

R.A. $16^h\ 11^m{\cdot}0$
Decl. + 34° 12′

				h m
1893·601	210°·5	4″·25	III.	19 15
1893·685	209·2	4·24	III.	20 45
1893·643	209·8	4·24		

No. 75. Σ 2078 = 17 *Draconis.* (6—6·5.)

R.A. $16^h\ 33^m{\cdot}3$
Decl. + 53° 9′

				h m
1893·601	110°·7	3″·79	III.	20 15
1893·685	113·1	3·76	III.	21 10
1893·724	111·7	3·66	III.	22 5
1893·670	111·8	3·74		

No. 76. Σ 2084 = ζ *Herculis.* (3—6·5.)

R.A. $16^h\ 37^m{\cdot}2$
Decl. + 31° 48′

				h m
1892·579	58°·7	1″·32	V.	19 40
1892·595	55·9	1·30	V.	20 0
1892·675	57·6	1·43	V.	20 15
1892·606	57·4	1·35		

				h m	
1894·620	35°·4	1″·16	V.	20 50	Bad seeing.
1894·639	40·9	—	V.	21 10	Clouded over.
1894·629	38·1	1·16			

No. 77. Σ 2094. (7·3—7·6.)

R.A. $16^h\ 39^m{\cdot}4$
Decl. + 23° 43′

				h m
1894·639	80°·2	1″·57	IV.	20 45

No. 78. Σ 2114 = P. XVI., 270. (6·2—7·4.)

R.A. 16ʰ 56ᵐ·7, Decl. + 8° 36′

	°	″		h m
1893·508	159·4	1·06	V.	17 55
1893·554	157·6	1·06	IV.	18 20
1893·531	158·5	1·06		

No. 79. Σ 2130 = μ *Draconis*. (5—5·1.)

R.A. 17ʰ 3ᵐ·1, Decl. + 54° 37′

	°	″		h m
1894·880	152·2	2·11	IV.	21 40
1894·896	151·2	2·69	IV.	22 50
1894·935	151·3	2·38	IV.	23 30
1894·904	151·6	2·39		

No. 80. Σ 2173. (5·8—6·1.)

R.A. 17ʰ 25ᵐ·2, Decl. − 0° 58′

	°	″		h m
1892·715	340·7	1·01	V.	19 30
1892·718	340·4	0·80	V.	20 45
1892·732	341·0	0·93	V.	19 25
1892·722	340·7	0·91		

No. 81. Σ 2199. (7·2—7·8.)

R.A. 17ʰ 36ᵐ·4, Decl. + 55° 49′

	°	″		h m
1892·795	94·4	1·95	IV.	23 55
1892·797	91·7	1·76	IV.	23 40
1892·808	91·7	1·97	IV.	20 40
1892·800	92·6	1·89		

No. 82. Σ 2262 = τ *Ophiuchi*. (5—5·7.)

R.A. 17ʰ 57ᵐ·0, Decl. − 8° 11′

	°	″		h m
1893·467	253·4	1·81	IV.	17 30
1893·477	254·5	1·88	IV.	17 25
1893·554	254·5	1·73	IV.	18 50
1893·499	254·1	1·81		

No. 83. Σ 2271. (7·3—8·3.)

R.A. 17ʰ 57ᵐ·9, Decl. + 52° 51′

	°	″		h m
1892·768	264·8	2·40	IV.	23 45
1892·795	265·6	2·32	IV.	23 35
1892·797	263·8	2·59	III.	23 15
1892·787	264·7	2·44		

No. 84. Σ 2272 = 70 *Ophiuchi*. (4·1—6·1.)

R.A. 18ʰ 0ᵐ, Decl. + 2° 33′

	°	″		h m
1892·486	322·2	2·31	IV.	17 50
1892·488	321·5	2·29	IV.	18 15
1892·507	321·4	2·19	IV.	18 0
1892·494	321·7	2·26		

	°	″		h m
1893·467	314·1	2·23	IV.	16 50
1893·469	313·7	2·20	IV.	18 0
1893·477	313·6	2·22	IV.	16 55
1893·471	313·8	2·22		

	°	″		h m
1894·524	306·1	2·23	IV.	18 25
1894·530	310·3	2·49	IV.	18 20
1894·568	306·0	2·14	IV.	19 0
1894·541	307·4	2·29		

No. 85. Σ 2368. (7·2—7·4.)

R.A. 18^h $36^m·2$, Decl. + 52° 13′

	°	″		h m
1892·768	325·6	1·96	IV.	0 25
1892·795	325·9	2·07	IV.	0 35
1892·797	326·8	2·05	IV.	0 5
1892·787	326·1	2·03		

No. 86. Σ 2455 = L 35821. (7·2—8·3.)

R.A. 19^h $2^m·2$, Decl. + 22° 0′

	°	″		h m
1892·811	86·9	3·73	III.	22 10
1892·817	91·2	3·71	III.	23 50
1892·926	87·7	3·48	III.	22 5
1892·851	88·6	3·64		

No. 87. Σ 2587. (6·5—9·2.)

R.A. 19^h $45^m·5$, Decl. + 3° 48′

	°	″		h m
1892·773	98·0	4·40	III.	20 50
1892·795	101·5	4·72	III.	22 55
1892·808	97·0	4·10	III.	19 55
1892·792	98·8	4·41		

No. 88. Σ 2671. (6—7·4.)

R.A. 20^h $15^m·7$, Decl. + 55° 3′

	°	″		h m
1894·858	338·1	3·15	IV.	2 10
1894·877	338·5	3·09	IV.	0 20
1894·880	339·6	2·96	IV.	22 50
1894·872	338·7	3·07		

No. 89. Σ 2723. (6·4—8·2.)

R.A. 20^h $39^m·7$, Decl. + 11° 55′

	°	″		h m
1892·811	94·5	1·52	IV.	23 5
1892·926	99·7	1·40	IV.	22 40
1892·868	97·1	1·46		

No. 90. Σ 2758 = 61 *Cygni*. (5·3—5·9.)

R.A. 21^h $2^m·2$, Decl. + 38° 10′

	°	″		h m
1894·844	122·9	21·23	IV.	1 15
1894·858	123·0	21·36	IV.	1 30
1894·851	122·95	21·29		

No. 91. Σ 2786. (7—8·1.)

R.A. 21^h $14^m·4$, Decl. + 9° 1′

	°	″		h m
1892·768	185·6	2·31	IV.	22 15
1892·771	185·3	2·52	IV.	23 50
1892·773	185·7	2·41	IV.	21 35
1892·771	185·5	2·41		

No. 92. Σ 2799 = 20 (B) *Pegasi*. (6·6—6·6.)

R.A. 21^h $23^m·3$, Decl. + 10° 36′

	°	″		h m	
1894·822	296·6	—	IV.	22 10	Clouded over.
1894·844	299·6	1·25	IV.	0 50	
1894·877	299·6	1·33	IV.	22 35	
1894·880	300·4	1·26	IV.	22 10	
1894·856	299·0	1·28			

No. 93. Σ 2804. (7·3—8.)

R.A. 21^h $27^m·5$, Decl. + 20° 14′

	°	″		h m
1892·808	330·8	2·83	IV.	23 5
1892·811	332·4	3·06	III.	22 40
1892·817	332·3	2·96	IV.	0 25
1892·812	331·8	2·95		

No. 94. Σ 2824 = κ *Pegasi*. (3·9—10·8.)

R.A. $21^h\ 39^m{\cdot}6$ Decl. + 25° 9′

	°	″		h m
1892·808	297·1	12·16	III.	0 20
1892·811	298·3	12·02	III.	23 35
1892·809	297·7	12·09		

No. 95. Σ 2877. (7·5—10·5.)

R.A. $22^h\ 9^m$ Decl. + 16° 39′

	°	″		h m
1892·808	358·3	10·95	III.	0 5
1892·811	358·4	11·06	III.	0 25
1892·809	358·35	11·00		

No. 96. Σ 2909 = ζ *Aquarii*. (4—4·1.)

R.A. $22^h\ 23^m{\cdot}2$ Decl. − 0° 36′

	°	″		h m
1892·732	323·7	3·22	IV.	22 50
1892·735	323·7	2·77	IV.	23 20
1892·768	323·4	2·99	IV.	22 40
1892·745	323·6	2·99		
	°	″		h m
1893·806	323·0	3·29	IV.	23 10
1893·828	323·3	3·16	IV.	0 20
1893·844	322·4	3·32	IV.	23 15
1893·826	322·9	3·26		
	°	″		h m
1894·735	324·0	3·24	IV.	23 20
1894·790	323·2	3·09	IV.	23 15
1894·803	321·8	3·22	IV.	0 25
1894·776	323·0	3·18		

No. 97. Σ 2944 = P. XXII. 219. (7·5—8—9.)

R.A. $22^h\ 42^m{\cdot}1$ Decl. − 4° 48′

A—B

	°	″		h m
1892·735	255·6	3·49	IV.	23 50
1892·768	255·1	3·28	IV.	23 5
1892·771	255·7	3·74	IV.	23 25
1892·758	255·5	3·50		

A—C

	°	″		h m
1892·735	134·5	47·16	IV.	24 0
1892·768	134·1	48·15	IV.	23 15
1892·752	134·3	47·66		

No. 98. Σ 3007. (6·5—9·5.)

R.A. $23^h\ 17^m{\cdot}5$ Decl. + 19° 57′

	°	″		h m
1894·880	81·8	6·07	III.	0 40
1894·896	81·7	5·59	III.	0 55
1894·935	81·4	6·25	III.	0 10
1894·904	81·6	5·97		

No. 99. Σ 3008. (7—8.)

R.A. $23^h\ 18^m$ Decl. − 9° 4′

	°	″		h m
1893·806	243·1	4·15	III.	23 40
1893·844	243·8	4·33	III.	23 50
1893·825	243·4	4·24		

A Determination of the Constant of Nutation from Greenwich Meridian Observations of Polaris 1836–1893. By W. G. THACKERAY.

(*Communicated by the Astronomer Royal.*)

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IN Professor HARKNESS' valuable appendix to the *Washington Observations* 1885, "The Solar Parallax and its Related Constants," will be found a collection of the most important determinations of the constant of nutation. One of these, an investigation by Mr. STONE of the Greenwich Transit Circle Observations 1851–1867 (*Mems. R.A.S.* vol. xxxvii.), gives the following values :—

$9''.115$	$-1.66\,p$	from R.A.	of Polaris
9.108	$+6.1\,\delta p$	N.P.D.	,,
9.144	$-3.6\,\delta c$	N.P.D.	,, Cephei 51
9.214	$+1.75\,\delta m$	N.P.D.	,, δ Ursæ Minoris

where p, δp, δc, and δm are corrections to the adopted proper motions of GOULD's *Standard Places of Fundamental Stars*, second edition, viz.,

Proper Motion of	Polaris.	Cephei 51.	δ Ursæ Minoris.
in R.A.	$+0^{s}.1148$		
N.P.D.	$-0''.004$	$+0''.048$	$-0''.043$

These values, with the exception of that from the observations of δ *Ursæ Minoris*, whether derived from observations of R.A. or N.P.D., are consistently smaller than the adopted value $9''\cdot224$. If the investigation had been confined to R.A.s or N.P.D.s only, it would be easy to imagine a systematic error in the observations to account for the discrepancy, but it would appear to be highly improbable that the Greenwich Meridian Observations, whether of Right Ascension or North Polar Distances, should be affected by systematic errors of such a character as would conspire to give a like value to the constant of nutation, and at the same time be both erroneous; though of course it is possible.

Since the publication of Professor HARKNESS' work, Professor NEWCOMB (*Astronomical Papers for the use of the American Ephemeris and Nautical Almanac*, vol. ii. pp. 476–490)* has discussed the Greenwich Meridian Observations 1851–1888 with reference to the value of this constant, and the result of this discussion as far as the R.A.s of *Polaris* are concerned is to give the value $9''\cdot153$ from the nodal period 1851–1869, and $9''\cdot242$ from the nodal period 1870–1888.

In the present investigation all the meridian observations of *Polaris* from 1836–1893 have been discussed. Part of these observations has formed the material of the above discussions; but, for several reasons, it seemed advisable to undertake afresh the discussion of the series as a whole.

The course of the paper is as follows :—

1. The Mean Right Ascensions of *Polaris* for the years 1836–1893 have been collected together and reduced to 1890·0, with an adopted proper motion of $+0^{s}\cdot1200$ for the epoch 1890·0.

2. An investigation has been made of the personal equation of the observers for these transits, and the personalities applied on the assumption that they do not vary with the time.

3. It is found that, if we may treat the personalities as not varying with the time, the successive changes in the observing staff lead to corrections

* See also "The Elements of the Four Inner Planets and the Fundamental Constants of Astronomy." By SIMON NEWCOMB. (Supplement to the *American Ephemeris and Nautical Almanac* for 1887.)

to the Mean Right Ascensions which alter the proper motion of *Polaris* to $+0^{s}\cdot1550$ for the epoch 1890·0.

4. (*a*) The uncorrected results, and (*b*) the results corrected for personality and proper motion, as above, have both been discussed to determine the constant of nutation.

The deduced values are :—

$$(a) \quad 9''\cdot147 \pm 0''\cdot056$$
$$(b) \quad 9\cdot120 \pm 0\cdot032$$

5. The North Polar Distances of *Polaris* have been similarly collected and reduced to 1890·0, with an adopted proper motion of $+0''\cdot005$ for the epoch 1890·0.

6. They have also been discussed to determine the constant of nutation. The deduced value is $9''\cdot161 \pm 0''\cdot027$.

The Right Ascensions of Polaris.

The Right Ascensions of *Polaris* are those given in the catalogues of the various volumes of Greenwich Observations, and depend on observations made with the Transit Instrument from 1836–1850, and with the Transit Circle from 1851–1893.

In order to reduce the observed places to 1890, which was adopted as the common epoch of reduction, the rigorous method given by CHAUVENET'S formula was adopted, and the value of the proper motion for the epoch 1890·0 was assumed to be $+0^{s}\cdot1200$. No corrections have been applied to any of the observations for variation in the value of the proper motion used in reducing any observation back to January 1 of any year. The deduced values are given in the following table :

Table I.

Right Ascensions of Polaris observed at Greenwich, 1836–1893, reduced to 1890 by Chauvenet's formula and an adopted proper motion for the epoch 1890 of $+0^{s}\cdot1200$.

Year.	Observed Right Ascension.	Adopted R.A. 1890·0.	Year.	Observed Right Ascension.	Adopted R.A. 1890·0.
	h m s	h m s		h m s	h m s
1836	1 1 6·07	1 18 30·21	1865	1 9 38·06	1 18 30·01
1837	22·45	30·62	1866	57·87	30·32
1838	38·63	30·58	1867	10 17·34	30·16
1839	55·24	30·86	1868	37·03	30·08
1840	2 11·08	30·17	1869	57·18	30·32
1841	27·35	30·01	1870	11 16·34	29·43
1842	43·60	29·46	1871	36·87	29·77
1843	3 0·86	30·15	1872	57·41	29·87
1844	17·40	29·85	1873	12 17·59	29·67
1845	34·53	29·93	1874	38·56	30·02
1846	51·20	29·53	1875	59·37	30·05
1847	4 9·43	30·83	1876	13 20·27	30·02
1848	26·06	30·04	1877	41·08	29·75
1849	43·89	30·63	1878	14 2·39	29·83
1850	5 0·81	29·78	1879	23·96	30·01
1851	19·03	30·48	1880	45·28	29·79
1852	36·76	30·47	1881	15 7·06	29·87
1853	54·66	30·61	1882	28·95	29·90
1854	6 12·98	30·98	1883	50·77	29·69
1855	30·86	30·63	1884	16 13·15	29·88
1856	49·36	31·06	1885	35·70	30·07
1857	7 7·36	30·67	1886	58·40	30·24
1858	25·89	30·74	1887	17 21·32	30·46
1859	44·22	30·38	1888	44·02	30·29
1860	8 3·16	30·71	1889	18 7·74	30·96
1861	21·50	30·11	1890	30·61	30·61
1862	40·52	30·16	1891	54·62	31·22
1863	59·63	30·17	1892	19 18·03	31·05
1864	9 19·08	30·49	1893	41·96	31·22

The resulting Right Ascensions thus reduced were graphically represented, to see what, if any, should be the correction to the assumed value of the proper motion. While the assumed value $+0^{s}\cdot1200$ seemed fairly correct, the resulting curve exhibited discordances larger than had been anticipated, and of a puzzling character. After some hesitation, owing to the heavy amount of work entailed, it was determined to investigate the subject of personality in observing a transit on the same lines as had been adopted in the case of the Sun (*Monthly Notices*, vol. liv. p. 7).

Some years ago a somewhat similar investigation was begun at Washington Observatory. From a discussion of the Right Ascensions of *Polaris* made during the years 1866 and 1867, it was found that there were such well-marked differences between different observers, that in the year 1868, for purposes of deducing Azimuth corrections, the computed places of *Polaris* were corrected by a table given in the Introduction to the Washington Observations, 1868, p. 12.

It is stated in the annual volumes of the Greenwich Observations that the observations of *Polaris* are only kept for place in those cases where two consecutive transits, one above and the other below pole, or *vice versâ*, have been observed, or similar observations of *Cephei* 51, δ or λ *Ursæ Minoris* have been secured; and as very often the consecutive transits are not made by the same observer, the deduced corrections for personality will to a certain degree be affected. On considering the nature of this disturbing cause, it will be evident that, while the personalities tabulated below are only a fraction (·6 or ·7) of the total personality in observing transits, yet they are the actual personalities which affect the Right Ascensions, and are thus rightly used in the sequel.

For the purpose of testing the subject of personality, all the observations in the year were arranged under the names of the different observers, the several means taken, and the differences between these means and the mean place for the year given by all the observations found, these differences being the correction to reduce an observer's mean to the annual mean, or, practically, the mean observer. When it was found that several of the occasional observers had not made sufficient observations to justify much value being attached to corrections formed upon scanty data, their observations have been rejected, and the annual mean corrected accordingly. For a standard Mr.

CRISWICK has been chosen, as his observations extend over the longest period, and are most conveniently placed for connecting the earlier and later periods. During the period over which his observations extend, each observer has been compared directly with him for the corresponding years during which he and they observed simultaneously. Thus the correction to any observer to reduce to C as standard is the difference of the weighted mean of that observer's and C's corrections to the annual mean as given in Table II. When C ceased to observe, the observers coming before and after him have been reduced to C through a third medium, whose observations extend simultaneously for some years both with C and with the others. Mr. CRISWICK's observations extend from 1853 to 1881. To connect the previous period 1836–1853 with C, we have used D and H—Mr. DUNKIN and Mr. HENRY—as the connecting links. For the later period 1881–1893 we have made use of Mr. DOWNING and Mr. LEWIS (A D and T L).

It will be well to state here distinctly that the following results are based on the assumption that the personal equation of C and the other connecting links remain constant for the period during which they observe, an assumption for which there is no actual justification, but which is the most workable hypothesis under the circumstances; for the quantities involved are small when compared with the accidental errors of observations, and the observations are not sufficiently numerous to allow of breaking a series of observations into arbitrary divisions. A small Table VI. follows, from which it will be seen that, while there are discrepancies between the different personalities of the various observers, when the periods over which their observations extend are broken up, yet the evidence, such as it is, would seem to point to the constancy of "C."

TABLE II.

Corrections to be applied to each observer's R.A. of Polaris to reduce to annual mean.

(+ means that the observer's R.A. is less, − that it is greater than the annual mean).

		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.
									H¹.						M.		E.	
	s		s		s		s		s		s		s		s		s	
1836	...		...		...		...		+ ·03	35	...		...		+ ·72	6	− ·13	52
1837	...		...		...		...		− ·01	46	...		...		+ ·26	12	− ·09	45
1838	...		...		...		...		·00	38	...		...		+ ·58	9	− ·44	48
1839	...		...		...		...		− ·16	20	...		...		...		+ ·10	38
1840	...		...		P.		...		− ·05	41	...		...		+ 1·59	8	− ·30	49
1841	...		...		+ ·37	4	J. H.		− ·14	27	...		...		+ ·55	14	− ·30	37
1842	...		D.		+ 1·27	6	+ 2·19	4	− ·05	35	...		...		+ ·38	8	− ·58	48
1843	...		·00	5	+ ·95	5	+ 1·02	8	+ ·21	24	R¹		...		− ·16	7	− ·71	37
1844	...		...		...		...		− ·32	14	+ ·50	9	H. B.		+ 1·56	8	− ·76	31
1845	...		+ ·40	2	...		...		− ·33	23	− ·55	14	+ 2·56	2	+ 1·33	4	− ·11	26
1846	...		+ ·67	26	...		+ 2·70	2	− ·38	26	− ·71	24	...		...		...	
1847	...		...		...		...		+ ·18	40	− ·61	48	+ 2·10	4	...		− ·31	2
1848	...		+ ·22	3	...		...		+ ·08	35	− ·15	51	...		+ ·97	4	...	
1849	...		− ·65	16	W. E.		...		+ ·47	13	+ ·05	41	...		+ 1·59	5	− ·32	16
1850	...		− 1·04	11	...		+ 1·07	2	− ·44	10	+ ·45	22	...		− ·24	3	+ ·25	18
1851	C.		− ·28	17	+ ·08	4	+ ·79	3	− ·31	20	− ·43	22	+ ·97	8	− ·71	7	+ ·73	16
1852	...		− ·81	30	...		+ 1·01	22	− ·52	18	− ·50	28	+ ·84	16	− 1·19	2	...	
1853	− ·81	5	− ·63	21	− ·13	11	+ 1·68	8	− ·42	15	+ ·74	5	+ ·85	3	− 1·47	2	H. T.†	
															L.			
1854	+ ·13	5	− ·89	20	− ·71	26	+ 1·94	8	− ·16	24	...		+ 1·60	5	+ ·97	15	...	
1855	+ ·12	23	− ·02	16	− 1·57	21	...		+ ·34	3	J. C.		+ ·95	2	− ·10	2	+ 1·08	8
1856	+ ·70	17	− ·36	16	− ·98	17	...		...		+ ·29	22	+ 1·58	5	+ ·34	3	+ ·27	10
1857	− ·03	31	− ·10	22	− ·42	34	...		...		− ·78	13	+ 1·19	2	+ ·31	29	+ ·05	5
1858	+ ·39	41	− ·46	33	− ·50	28	...		...		+ ·10	11	...		− ·34	31	...	
1859	+ ·58	29	− ·53	26	− ·31	22	R².		...		+ ·11	27	...		+ ·06	3	...	
1860	+ ·73	11	− ·06	17	− ·06	22	...		...		− ·42	11	...		...		N.	
1861	+ ·13	14	− 1·11	7	− ·86	12	+ ·45	21	...		− ·20	14	...		...		+ ·45	20
1862	+ ·12	11	− ·28	4	− ·28	8	− ·07	10	...		+ ·30	4	...		...		+ ·39	6
1863	+ ·65	15	− ·69	15	− ·66	18	+ ·84	11	...		+ ·33	5	...		...		+ ·21	6

TABLE II.—*Continued.*

		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.		No. of Obs.
	C.		D.		W. E.		R².		H.		J. C.		H. B.		L.		N.	
	s		s		s		s		s		s		s		s		s	
1864	+ ·48	23	− ·66	21	− ·09	23	+ ·77	11	...		− ·28	15	...		...		...	
1865	+ ·18	25	− ·74	19	+ ·35	18	...		...		+ ·07	16	...		...		...	
1866	+ ·28	15	− ·23	16	− ·13	13	...		H. C.		+ ·03	15	...		...		...	
1867	+ ·59	14	− ·35	20	− ·15	15	...		+ 1·12	6	+ ·08	8	...		...		...	
1868	+ ·47	25	− 1·24	28	+ ·71	16	...		+ ·41	13	+ ·33	22	...		(L. cont.)		...	
1869	+ 1·27	16	− ·93	16	+ ·16	10	...		+ ·06	6	− ·58	14	G.		...		J.	
1870	+ ·46	20	...		− ·60	16	...		+ ·16	17	− 1·08	17	...		+ ·61	11	+ 1·10	7
1871	+ ·19	18	...		− ·69	9	A. D.		+ ·49	11	− ·23	11	− ·46	10	+ ·21	10	+ ·82	5
1872	− ·17	25	...		− ·33	11	...		+ ·48	5	− ·37	15	+ ·16	7	+ ·16	26	+ ·71	7
1873	− ·72	24	T.		− ·26	11	+ ·34	21	− 1·10	4	...		+ ·34	8	+ ·29	13	+ ·50	12
1874	− ·80	21	...		− ·62	15	+ ·13	21	...		...		− ·25	6	+ ·74	27	+ ·28	3
1875	− ·35	12	− ·42	17	...		+ ·35	15	...		H. P.		...		+ ·95	12	− ·85	8
1876	− ·59	24	− ·38	21	...		+ ·57	19	R³		+ ·44	9	J. P.		+ ·83	11	...	
1877	− ·52	13	+ ·20	20	...		− ·12	13	− ·70	6	+ ·78	6	− ·28	10	+ ·78	12	T. P.	
1878	− ·99	16	+ ·27	10	...		− ·76	3	− ·20	9	+ ·92	12	+ ·53	14	...		...	
1879	− ·09	13	+ ·56	12	T. L.		+ ·03	9	− 1·10	9	+ ·59	6	...		...		− ·01	10
1880	− ·34	13	+ ·22	15	...		+ ·28	11	...		+ ·26	11	− ·73	7	A. P.		+ ·02	7
1881	− ·16	15	+ ·13	15	− ·40	24	+ ·05	18	H².		+ 1·17	9	+ ·57	3	...		+ ·38	6
1882	...		+ ·92	18	+ ·13	15	− ·16	15	+ ·23	25	− 1·39	12	− ·58	5	+ ·14	5	S. D.	
1883	...		+ ·56	11	− ·12	23	− ·13	21	− ·40	17	+ ·23	3	− ·02	3	− ·11	6	+ ·58	5
1884	H. T.*		+ ·51	13	+ ·24	18	+ ·03	17	− ·17	25	R. W.		+ 1·07	4	− ·49	8	+ ·36	12
1885	− 1·27	3	+ ·14	4	− ·21	21	− ·10	19	+ ·03	28	+ ·10	7	− ·66	5	+ ·54	12	+ ·18	5
1886	− ·68	9	− ·05	12	+ ·05	25	+ ·21	6	+ ·31	22	− ·28	8	...		+ ·46	5	− ·86	4
1887	− 1·07	5	− ·32	12	+ ·07	18	− ·08	11	·00	21	− ·41	5	+ ·89	4	+ 1·36	2	...	
1888	...		+ ·03	21	− ·29	12	− ·31	9	− ·06	16	+ ·25	4	+ ·24	5	+ ·31	5	...	
1889	...		− ·38	13	+ ·29	23	− ·97	17	− ·03	16	+ ·54	5	...		...		...	
1890	...		− ·45	13	+ ·75	9	− ·07	13	− ·24	27	...		B.		A. C.		T. H.	
1891	...		− ·21	9	− ·01	5	− ·22	3	− ·07	11	...		...		− ·43	8	...	
1892	...		...		+ ·53	16	...		...		...		− ·64	25	+ ·03	35	+ ·23	23
1893	...		...		− ·14	6	...		− ·19	30	...		+ ·02	57	− ·32	45	− ·27	14

The initials are as follows :

B. = Mr. Bryant	G. = Mr. Goldney	A. P. = Mr. Alfred Pead
H. B. = „ Breen	H.[1] = „ Henry	H. P. = „ Henry Pead
C. = „ Criswick	H.[2] = „ Hollis	J. P. = „ John Power
A. C. = „ Crommelin	J. H. = „ Hind	T. P = „ Thomas Plucknett
H. C. = „ Henry Carpenter	T. H. = „ Hudson	R.[1] = „ Rogerson
J. C. = „ James Carpenter	J. = „ Jenkins	R.[2] = „ Roberts
D. = „ Dunkin	L. = „ Lynn	R.[3] = „ Robinson
A. D. = „ Downing	T. L. = „ Thomas Lewis	T. = „ Thackeray
S. D. = „ Dolman	M. = Rev. R. Main	H.T.* = Prof. Turner
E. = „ Thomas Ellis	N. = Mr. Newcomb	H.T.† = Mr. Henry Taylor
W. E. = „ William Ellis	P. = „ Paul	R.W. = „ Woodgate

There is one other circumstance that should be mentioned in connection with this table, and that is, that as Mr. Lynn observed during two series of years, separated by an interval of ten years, we have preferred to treat him as though he were a new observer and give him two personal equations.

The number of observations on which each result depends is subscribed, and constitutes the weight for taking the mean.

The following Table III. gives the corrections that are required to convert an observation made by B., H. B., A. C., &c., into what it would have been if it had been made by C.

TABLE III.

Corrections to reduce observed R.A. of Polaris by different observers to "C" as standard.

(+ means that the observer's R.A. is larger, − that it is smaller than that of "C.")

Period.	Observer.	Correction in time.	Correction in arc.	Period.	Observer.	Correction in time.	Correction in arc.
		s	″			s	″
1836–55	C—H.	+0·79	+0·29		C—H. C.	−0·08	−0·03
	C—M.	−0·12	−0·04		C—J.	−0·64	−0·24
	C—E.	+0·96	+0·36	1877–79	C—R.	+0·10	+0·04
1844–53	C—R.	+0·87	+0·32		C—T. P.	−0·89	−0·33
	C—J. H.	−0·72	−0·27		C—T.	−0·58	−0·21
	C—H. B.	−0·54	−0·20	1882–93	C—H.	−0·92	−0·34
	C—P.	+0·74	+0·27	1885–87	C—H. T.	+0·10	+0·04
	C—D.	+0·81	+0·31		C—T. L.	−0·92	−0·34
	C—W. E.	+0·77	+0·28		C—H. P.	−0·99	−0·37
1854–59	C—L.	+0·16	+0·06		C—J. P.	−0·88	−0·33
1870–77	C—L.	−0·87	−0·32		C—A. P.	−1·03	−0·39
1855–57	C—H. T.	−0·31	−0·11		C—S. D.	−1·05	−0·39
1861–64	C—R.	−0·12	−0·04		C—B.	−0·42	−0·16
	C—J. C.	+0·58	−0·21		C—A. C.	−0·45	−0·17
	C—A. D.	−0·76	−0·28		C—T. H.	−0·61	−0·23
	C—N.	−0·07	−0·03		C—R. W.	−1·08	−0·40

The periods of observation are given in a few cases where different observers in a course of years have had the same initials in order to prevent confusion, and in the case of L to distinguish the two periods of observation.

The quantities in Table III. reduced to equatorial time give $0^{\mathrm{s}}\cdot05$ as an extreme range of discordance, a quantity which compares very favourably with the ordinary personal equations derived from clock stars.

The system of making an observation of the Transit of *Polaris* has remained practically unaltered till 1889, when, in place of estimating the time by the clock when the star was apparently bisected by the wire (the eye and ear method), the wire itself, by moving the transit micrometer, was made to bisect the star, and the moment of the apparent bisection was recorded on the

chronograph, and the reading of the micrometer head was simultaneously taken (the galvanic method). A few observations of *Polaris* taken by both methods at the same transit give the following results, the general conclusion appearing to be that the change in the system of observing has tended to diminish the R.A. of *Polaris*, and that the rise in the curve since 1889 would have been, if anything, greater under the old system :

TABLE IV.

Differences of R.A. of Polaris from observations at the same transit made by the Galvanic and E and E methods. Differences taken Galvanic – (E and E).

H. T.	L.	A. D.	T.	W. R.	H.
s –0·38	+0·44	s –2·04	s +0·20	s –0·48	s +1·36
...	–1·51	–0·96	+0·01	–1·16	–2·03
...	–1·36	+1·21	–0·46	+0·02	–1·17
...	+0·70	+0·18	...	+1·36	–0·57
...	+0·83	–2·05	...	–1·71	–3·09
...	–0·68	+1·25	...	–0·45	–0·29
...	–0·09	–0·94	...	–1·48	–2 84
...	...	...	...	–1·93	–3·54
...	...	...	...	...	–1·48
...	...	...	...	...	–3·03
Mean –0·38	–0·24	–0·48	–0·08	–0·73	–1·66

The two following Tables V. and VI. exhibit an analysis of the observations, to detect, if possible, the character of the correction for personality, and also any periodic change in the standard observer "C," as compared with the other ordinary observers.

Table V. gives for the years 1868–1893 (the previous years' results are not immediately available for the purpose) the observations of *Polaris* for each observer, both above and below pole, from which it would appear that the correction for personality is a question of lateness or earliness in estimating the time of transit, and is the same for both directions of apparent motion.

TABLE

Corrections to be applied to each observer's R.A. of Polaris

(+ means that the observer's R.A. is less,

	D.		C.		E.		J. C.		L.		A. D.	
	s	S. P. s	s	S. P. s	s	S. P. s	s	S. P. s	s	S. P. s	s	S. P. s
1868	−1·57 12	− ·66 15	+ ·18 13	+ ·75 12	+ ·82 5	+ ·65 11	+ ·41 13	+ ·21 9	...	...	...	...
1869	− ·68 8	−1·18 8	+1·48 8	+1·06 8	+ ·17 5	+ ·16 5	− ·67 8	− ·46 6	...	...	...	...
1870	...	...	+ ·68 10	+ ·24 10	−1·06 9	− ·01 7	−1·28 9	− ·86 8	+ ·02 5	+ ·73 6	...	...
1871	...	...	+ ·09 11	+ ·36 7	− ·88 6	− ·39 3	− ·07 6	− ·43 5	+ ·21 5	+ ·21 5	...	...
1872	...	...	− ·11 13	− ·24 12	− ·37 4	− ·31 7	− ·09 6	− ·55 9	+ ·14 14	+ ·18 12	...	...
1873	...	...	− ·85 10	− ·36 7	− ·07 4	− ·36 11	...	...	+ ·14 8	+ ·52 5	+ ·36 11	+ ·31 10
1874	...	...	− ·83 11	− ·78 10	− ·52 5	− ·67 10	...	...	+ ·78 11	+ ·72 16	+ ·01 11	+ ·25 10
1875	...	...	− ·44 6	− ·26 6	...	...	...	...	− ·59 6	−1·31 6	− ·35 8	−1·15 7
1876	...	...	− ·46 15	− ·78 10	...	...	...	...	+ ·39 7	+1·41 4	+ ·69 9	+ ·46 10
1877	...	...	−1.13 7	− ·26 6	...	...	...	...	+1·25 3	+ ·63 9	−1·18 4	+ ·06 9
1878	...	...	− ·97 9	− ·78 14	...	...	...	...	...	...	− ·24 2	−1·74 1
1879	...	...	− ·09 6	− ·09 6	...	...	...	...	...	...	− ·59 5	+ ·82 4
1880	...	...	− ·22 7	−1·02 7	...	...	...	...	...	...	− ·03 5	+ ·52 6
1881	...	...	− ·52 7	− ·09 7	...	...	...	...	...	...	− ·41 9	− ·61 9
1882	...	...	...	− ·48 6	...	...	...	...	...	...	− ·13 7	− ·19 8
1883	...	...	...	+ ·16 8	...	...	...	...	...	...	− ·04 11	− ·23 10
1884	...	...	...	...	...	...	...	...	...	...	+ ·03 10	·00 7
1885	...	...	...	...	...	...	...	...	...	...	− ·02 6	− ·14 13
1886	...	...	...	...	...	...	...	...	...	...	+1·18 2	− ·22 4
1887	...	...	...	...	...	...	...	...	...	...	+ ·20 5	− ·31 6
1888	...	...	...	...	...	...	...	...	...	...	− ·86 2	− ·15 7
1889	...	...	...	...	...	...	...	...	...	...	− ·63 9	− ·11 8
1890	...	...	...	...	...	...	...	...	...	...	− ·17 6	+ ·02 7
1891	...	...	...	...	...	...	...	...	...	...	+ ·07 1	− ·22 2
1892	...	...	...	...	...	...	...	...	...	...	...	...
1893	...	...	...	...	...	...	...	...	...	...	...	...
Mean	−1·21 20	− ·84 23	− .22 133	− ·10 120	− ·38 38	− ·11 54	− ·30 42	−· 40 37	+ ·25 59	+ ·40 63	− ·09 123	− ·06 138

V.

(*above and below pole*) *to reduce to annual mean.*

— that it is greater than the annual mean.)

T.		T. L.		H.		A. C.		B.		T. H.	
s	S. P. s	s	S. P. s	s	S. P. s	s	S. P. s	s	S. P. s	s	S. P. s
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...
− ·32 4	− ·45 13	...	...	...	...	...	...	...	...	...	...
− ·33 10	− ·52 11	...	...	...	...	...	...	...	...	...	...
+ ·44 12	− ·16 8	...	...	...	...	...	...	...	...	...	...
− ·10 6	+ ·88 4	...	...	...	...	...	...	...	...	...	...
+ ·31 3	+ 1·10 8	...	...	...	...	...	...	...	...	...	...
− ·55 7	+ ·02 8	...	...	...	...	...	...	...	...	...	...
+ ·54 6	+ ·40 8	− ·26 13	− ·57 11	...	...	...	...	...	...	...	...
+ ·79 8	+ ·57 9	+ ·38 9	− ·25 6	− ·21 14	+ ·49 10	...	...	...	...	...	...
+ ·58 5	+ ·54 6	− ·48 11	+ ·29 12	− ·25 9	− ·58 8	...	...	...	...	...	...
+ 1·11 5	+ ·13 8	+ ·45 10	− ·03 8	− ·28 12	− ·07 13	...	...	...	...	...	...
+ ·41 4	+ ·03 10	− ·57 13	+ ·37 16	− ·17 12	+ ·18 16	...	...	...	...	...	...
− ·06 6	− ·05 6	− ·08 13	+ ·20 12	+ ·32 10	+ ·30 12	...	...	...	...	...	...
− ·29 5	− ·34 7	− ·01 11	+ ·18 7	− ·30 10	+ ·28 11	...	...	...	...	...	...
+ ·09 12	− ·05 9	− ·39 7	− ·16 5	− ·08 8	− ·03 8	...	...	...	...	...	...
− ·27 6	− ·47 7	− ·14 11	+ ·61 12	− ·01 8	+ ·06 8	...	...	...	...	...	...
+ ·91 5	+ ·56 4	− ·27 7	− ·67 6	− ·36 15	− ·26 12	...	...	...	...	...	...
+ ·21 3	− ·42 6	− ·32 3	+ ·45 2	− ·03 6	− ·12 5	− ·42 4	+ ·06 4	...	...	...	...
...	...	+ ·46 8	+ ·61 8	...	...	− ·08 16	+ ·14 19	− ·27 14	− 1·10 11	+ ·44 11	+ ·06 12
...	...	+ ·79 4	+ 1·25 1	+ ·91 13	− ·36 30	− ·14 24	− ·52 21	− ·08 26	+ ·11 31	− ·63 8	+ ·20 6
+ ·19 107	+ ·05 132	− ·08 120	+ ·14 106	− ·04 117	− ·05 133	− ·14 44	− ·19 44	− ·15 40	− ·21 42	− ·01 19	+ ·11 18

Table VI. merely breaks up into arbitrary periods the time during which the observations extend, to see if the apparent run up in Table VII. can be accounted for by a gradual change in "C."

Table VI.

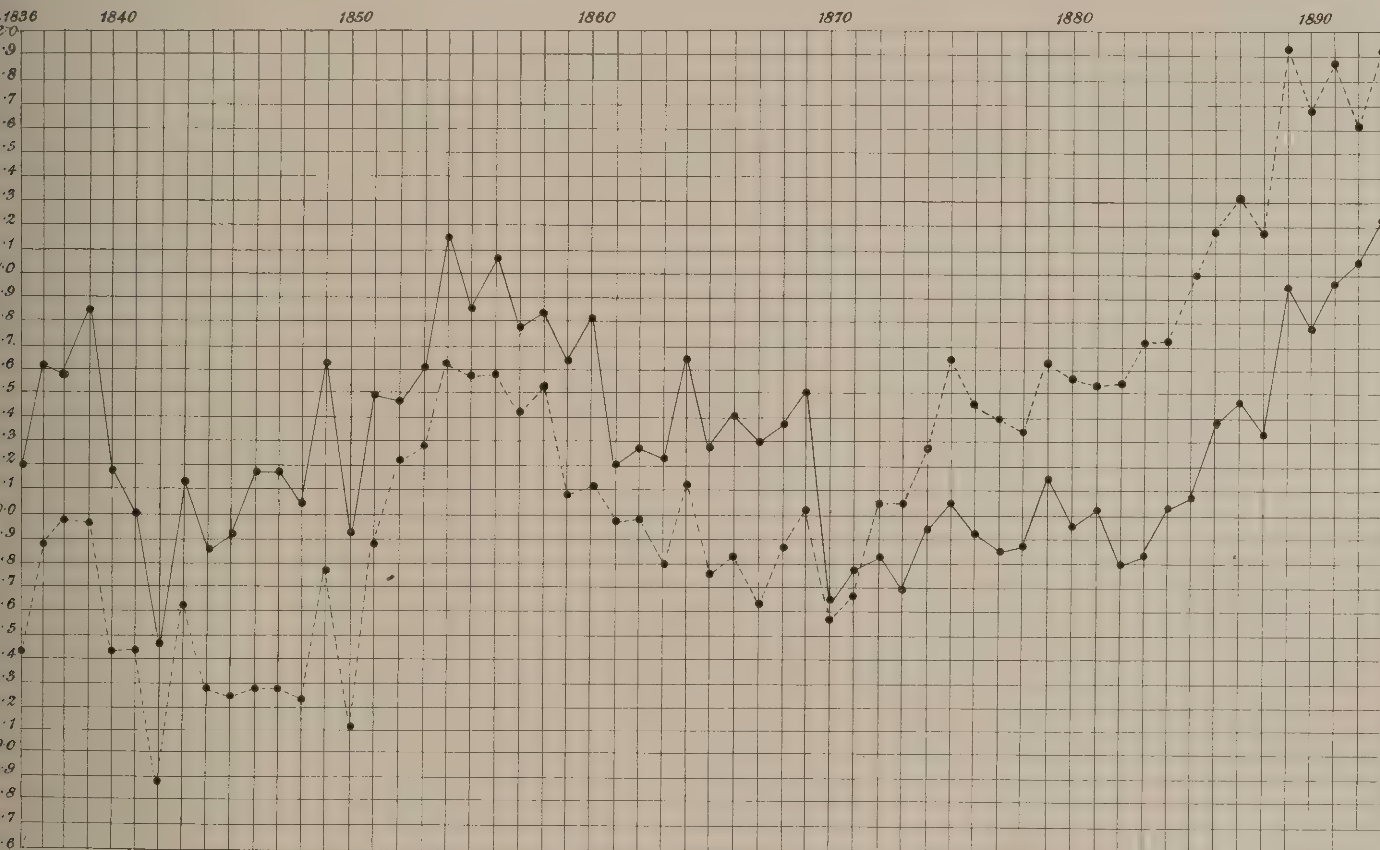
Analysis of personality to detect any changes in the Standard Observers.

Period.	H.—E.	H.—D.	H.—R.	C.—D.	C.—W.E.	C.—J. C.	C.—L.	C.—A. D.	C.—T.	A. D.—T.
	s	s	s	s	s	s	s	s	s	s
1836–41	+·16	...	...	...	...	...	...	...	...	...
1842–51	+·32	...	...	...	...	...	...	...	...	...
1843–50	...	−·01	+·12	...	...	...	...	...	...	...
1851–54	...	+·27	+·23	...	...	...	...	...	...	...
1853–60	...	...	...	+·06	+·91	+·36	...	...	...	...
1854–59	...	...	...	...	...	...	− ·38	...	...	...
1860–71	...	...	...	+·34	+·43	+·57	...	...	...	...
1870–73	...	...	...	...	+·38	...	...	...	...	...
1873–76	...	...	...	...	...	...	...	−·94	...	...
1870–77	...	...	...	...	...	...	−1·43	...	...	...
1875–81	...	...	...	...	...	...	...	...	−·58	...
1875–83	...	...	...	...	...	...	...	...	...	−·17
1877–81	...	...	...	...	...	...	...	−·45	...	...
1884–91	...	...	...	...	...	...	...	...	...	−·12

Table VII. is formed by applying the quantities in Table III. to Table II.; that is, we can correct the result of any observer's observation to what it would have been had it been made by C. The mean of all these different quantities weighted according to the number of observations made by the different observers in any year constitutes the correction to the adopted mean R.A. to make the result what it would have been had "C" taken all the observations. Applying these corrections to the adopted R.A.s reduced to 1890, as in Table I., slightly corrected where necessary for the rejection of the results of those observers whose personalities were not sufficiently determined, as previously explained, we finally have each year's R.A. reduced to 1890, with P.M. + $0^s\cdot1200$ referred to "C" as standard, that is, as though all the observations had been made by "C." The accompanying diagram (Plate 6) will show more clearly what is the effect of the correction for personality on the annual right ascensions.

(1) Right Ascensions of Polaris 1836-93 reduced to 1890 with adopted P.M. + $0^s.1200$ for Epoch 1890.

(2) The same referred to "C" as standard.



(1) ————

(2) •-------•-------• adopted correction to P.M. $\frac{1.75}{50}$

The mean of the results for 1846 and 1847 have been used in this diagram

Spottiswoode & C° Lith. London.

TABLE VII.

Adopted Right Ascensions of Polaris 1836–1893 *reduced to* 1890, *with* P.M. + 0ˢ·1200, *corrections for personality to reduce to "C" as Standard and adopted Right Ascensions, referred to C as standard, with* P.M. + 0ˢ·1550.

Year.	Adopted R.A. 1890. P.M. + 0ˢ·1200.	No. of Obs.	Corr. to adopted R.A. to reduce to C as standard.	Secs. of R.A. 1890, reduced to C. P.M. + 0ˢ·1200.	Secs. of R.A. 1890, reduced to C. P.M. + 0ˢ·1550.
	h m s		s	s	s
1836	1 18 30·21	73	−0·78	29·43	31·32
1837	30·62	103	−0·74	29·88	31·74
1838	30·58	95	−0·61	29·97	31·79
1839	30·86	58	−0·90	29·96	31·74
1840	30·17	98	−0·75	29·42	31·17
1841	30·01	82	−0·59	29·42	31·13
1842	29·46	101	−0·57	28·89	30·57
1843	30·15	85	−0·51	29·64	31·28
1844	29·85	62	−0·56	29·29	30·90
1845	29·93	71	−0·68	29·25	30·82
1846	29·53*	78	−0·92	28·61*	30·15*
1847	30·83*	94	−0·88	29·95*	31·45*
1848	30·04	93	−0·80	29·24	30·71
1849	30·63	91	−0·86	29·77	31·20
1850	29·92	66	−0·81	29·11	30·51
1851	30·48	87	−0·60	29·88	31·24
1852	30·47	116	−0·25	30·22	31·55
1853	30·61	70	−0·33	30·28	31·57
1854	31·15	103	−0·52	30·63	31·89
1855	30·83	75	−0·27	30·56	31·78
1856	31·06	90	−0·49	30·57	31·76
1857	30·77	136	−0·35	30·42	31·57
1858	30·84	144	−0·30	30·54	31·66
1859	30·63	107	−0·55	30·08	31·16
1860	30·81	61	−0·69	30·12	31·17
1861	30·21	88	−0·23	29·98	30·99
1862	30·26	43	−0·27	29·99	30·97
1863	30·23	70	−0·43	29·80	30·74

* The mean of these two results has been used.

TABLE VII.—*Continued.*

Year.	Adopted R.A. 1890. P.M. + 0^s·1200.	No. of Obs.	Corr. to adopted R.A. to reduce to C as standard.	Secs. of R.A. 1890, reduced to C. P.M. + 0^s·1200.	Secs. of R.A. 1890, reduced to C. P.M. + 0^s·1550.
	h m s		s	s	s
1864	1 18 30·65	93	−0·53	30·12	31·03
1865	30·26	78	−0·52	29·74	30·61
1866	30·42	59	−0·58	29·84	30·68
1867	30·30	63	−0·67	29·63	30·43
1868	30·38	104	−0·51	29·87	30·64
1869	30·52	62	−0·50	30·02	30·75
1870	29·63	88	−0·06	29·57	30·27
1871	29·77	64	−0·10	29·67	30·33
1872	29·83	89	+0·23	30·06	30·69
1873	29·67	92	+0·39	30·06	30·65
1874	29·94	95	+0·33	30·27	30·83
1875	30·05	70	+0·60	30·65	31·17
1876	29·92	84	+0·52	30·44	30·93
1877	29·85	80	+0·55	30·40	30·85
1878	29·88	64	+0·47	30·35	30·77
1879	30·15	59	+0·48	30·63	31·01
1880	29·95	64	+0·63	30·58	30·93
1881	30·02	90	+0·52	30·54	30·85
1882	29·80	95	+0·75	30·55	30·83
1883	29·83	89	+0·88	30·71	30·95
1884	30·02	94	+0·72	30·74	30·95
1885	30·07	104	+0·92	30·99	31·16
1886	30·38	91	+0·80	31·18	31·32
1887	30·46	78	+0·85	31·31	31·42
1888	30·34	72	+0·83	31·17	31·24
1889	30·96	74	+0·97	31·93	31·97
1890	30·77	62	+0·92	31·69	31·69
1891	30·98	36	+0·91	31·89	31·85
1892	31·05	99	+0·56	31·61	31·54
1893	31·22	152	+0·71	31·93	31·83
Means	30·314	4885	−0·09	30·222	31·116

It is now evident that the application of the correction for personality, while it has not materially smoothed the original discordances, has considerably upset the adopted proper motion—a result which was quite unexpected.

The apparent correction for proper motion for the epoch 1890 now becomes $+0^{s}\cdot1550$, and the adopted right ascensions reduced to "C" as standard with this proper motion are given in column 6 of Table VII.

The observations are now in a condition to test the correctness of the value of the nutation constant adopted in the *Nautical Almanac*, but before doing so it will be necessary to examine into the values that have been used throughout the years under discussion, and at the same time it will be convenient to also examine into the values of the adopted aberration and precession constants.

Period.	Aberration.	Nutation.	Precession.
1836–49	$20''\cdot36$	$9''\cdot25$	$m=46''\cdot0206 \quad n=20''\cdot0426$
1850–56	20·42	9·25	$m=46\cdot0591 \quad n=20\cdot0547$
1857–93	20·445	9·224	$m=46''\cdot0623+0''\cdot0002849\,(A-1800)$ $n=20\cdot0607-0\cdot0000863\,(A-1800)$

We have got three full periods of the Moon's nodes to deal with, on two suppositions—(*a*) uncorrected; (*b*) corrected for personality, and if we arrange the annual mean right ascensions, giving equal weights to each year's results in periods of nineteen years, and take the means of the three sets of determinations, and from each of these means take away the general mean, we shall have a series of quantities which should be directly proportional to the factor for nutation, for the mean year 1855, &c., and if α = the general mean, and α' the means of each of the three determinations, then

$$\alpha'-\alpha=\text{KNH},$$

where KN is the tabular amount of nutation in right ascension, and H the factor by which N must be multiplied to obtain the actual correction to nutation in right ascension. Then adopting the values for KN from Professor Newcomb's paper on the constant of nutation (referred to on p. 81) for the mean years 1855, 1856, &c., and discarding the fractional parts which have no serious effect on the result, we obtain the following corrections to the

adopted value of the constant of nutation, 9″·233. This value is obtained by giving a weight of 1 to the value 9″·25 used for the first nodal period, and a weight of 2 to the value 9″·224 used in the two latter nodal periods.

Table VIII. (*a*)

Right Ascensions of Polaris 1836–1892 *reduced to* 1890 *with adopted P.M.* $+0^s{\cdot}1200$ *for epoch* 1890, *and arranged in periods of nineteen years.*

	s	s	s	s	s	s	s	s	s	s	* s	* s	s	s	s	s	s	s	s	Mean. s
1836–1854	30·21	30·62	30·58	30·86	30·17	30·01	29·46	30·15	29·85	29·93	30·18	30·18	30·04	30·63	29·78	30·48	30·47	30·61	30·98	30·29
1855–1873	30·63	31·06	30·67	30·74	30·38	30·71	30·11	30·16	30·17	30·49	30·01	30·32	30·16	30·08	30·32	29·43	29·77	29·87	29·67	30·37
1874–1892	30·02	30·05	30·02	29·75	29·83	30·01	29·79	29·87	29·90	29·69	29·88	30·07	30·24	30·46	30·29	30·96	30·61	31·22	31·05	30·25
$\alpha'=$	30·29	30·58	30·42	30·44	30·13	30·24	29·79	30·06	29·97	30·04	30·02	30·19	30·11	30·39	30·13	30·29	30·28	30·57	30·57	...
$\alpha=$	30·26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\alpha'-\alpha=$	+·03	+·32	+·16	+·18	−·13	−·02	−·47	−·20	−·29	−·22	−·24	−·07	−·15	+·13	−·13	+·03	+·02	+·31	+·31	...

Corresponding Equations for Corrections to Constant of Nutation.

		C−O.			C−O.
	s	s		s	s
1855	$-22\mu=+0{\cdot}03$	+·17	1865	$+24\mu=-0{\cdot}24$	+·02
1856	$-24\ =+0{\cdot}32$	−·10	1866	$+25\ =-0{\cdot}07$	−·16
1857	$-23\ =+0{\cdot}16$	+·05	1867	$+22\ =-0{\cdot}15$	−·05
1858	$-20\ =+0{\cdot}18$	+·01	1868	$+17\ =+0{\cdot}13$	−·29
1859	$-15\ =-0{\cdot}13$	+·27	1869	$+10\ =-0{\cdot}13$	+·04
1860	$-\ 8\ =-0{\cdot}02$	+·09	1870	$+\ 2\ =+0{\cdot}03$	−·05
1861	$+\ 1\ =-0{\cdot}47$	+·46	1871	$-\ 7\ =+0{\cdot}02$	+·05
1862	$+\ 9\ =-0{\cdot}20$	+·12	1872	$-15\ =+0{\cdot}31$	−·17
1863	$+16\ =-0{\cdot}29$	+·14	1873	$-21\ =+0{\cdot}31$	−·12
1864	$+21\ =-0{\cdot}22$	+·03			

$$302\mu=-2{\cdot}82,\ \text{or}\ \mu=-0{\cdot}0934$$

Table VIII. (*b*)

Right Ascensions of Polaris 1836–1892 *reduced to* 1890·0 *with adopted P.M.* $+0^s{\cdot}1550$ *for epoch* 1890, *corrected to "C" for standard, and arranged in periods of nineteen years.*

	s	s	s	s	s	s	s	s	s	s	* s	* s	s	s	s	s	s	s	s	Mean. s
1836–1854	31·32	31·74	31·79	31·74	31·17	31·13	30·57	31·28	30·90	30·82	30·80	30·80	30·71	31·20	30·51	31·24	31·55	31·57	31·89	31·20
1855–1873	31·78	31·76	31·57	31·66	31·16	31·17	30·99	30·97	30·74	31·03	30·61	30·68	30·43	30·64	30·75	30·27	30·33	30·69	30·65	30·94
1874–1892	30·83	31·17	30·93	30·85	30·77	31·01	30·93	30·85	30·83	30·95	30·95	31·16	31·32	31·42	31·24	31·97	31·69	31·85	31·54	31·17
$\alpha'=$	31·31	31·56	31·43	31·42	31·03	31·10	30·83	31·03	30·82	30·93	30·77	30·88	30·82	31·09	30·83	31·16	31·19	31·37	31·36	...
$\alpha=$	31·10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$\alpha'-\alpha=$	+·21	+·46	+·33	+·32	−·07	·00	−·27	−·07	−·28	−·17	−·33	−·22	−·28	−·01	−·27	+·06	+·09	+·27	+·26	...

* This is the mean of the results of these two years.

Corresponding Equations for Corrections to Constant of Nutation.

		C–O.			C–O.
	s	s		s	s
1855	$-22\mu = +\cdot21$	$+\cdot06$	1865	$+24\mu = -\cdot33$	$+\cdot03$
1856	$-24 = +\cdot46$	$-\cdot16$	1866	$+25 = -\cdot22$	$-\cdot09$
1857	$-23 = +\cdot33$	$-\cdot05$	1867	$+22 = -\cdot28$	$+\cdot01$
1858	$-20 = +\cdot32$	$-\cdot07$	1868	$+17 = -\cdot01$	$-\cdot20$
1859	$-15 = -\cdot07$	$+\cdot11$	1869	$+10 = -\cdot27$	$+\cdot15$
1860	$-8 = \cdot00$	$+\cdot10$	1870	$+2 = +\cdot06$	$-\cdot08$
1861	$+1 = -\cdot27$	$+\cdot26$	1871	$-7 = +\cdot09$	$\cdot00$
1862	$+9 = -\cdot07$	$-\cdot04$	1872	$-15 = +\cdot27$	$-\cdot09$
1863	$+16 = -\cdot28$	$+\cdot08$	1873	$-21 = +\cdot26$	$\cdot00$
1864	$+21 = -\cdot17$	$-\cdot09$			

Whence $302\mu = -3\cdot71$, or $\mu = -0\cdot01228$

The resulting value of the nutation then becomes from

(*a*) Observed right ascensions of *Polaris* reduced to 1890 with P.M. $+0^s\cdot1200$ for epoch 1890 } $9''\cdot147 \pm 0\cdot056$.

(*b*) Right ascensions of *Polaris* reduced to "C" as standard and to 1890 with P.M. $+0^s\cdot1550$ for epoch 1890 } $9''\cdot120 \pm 0\cdot032$.

If we separate the three nodal periods, then the coefficient of H will be rather smaller for the first period, and rather larger for the second period, and we shall have

	1836–54.	1855–73.	1874–92.
	"	"	"
(*a*)	9·111	9·171	9·148
(*b*)	9·094	9·080	9·198

The following diagrams (Plate 7, curves A and B) give the residual curves after the correction to the nutation shown by the observations has been applied. The results cannot be said to be materially improved either by the correction for personality or the nutation. The best thing that can be said for the correction for personality is that it tends to unite the peculiar break shown to exist between the results of the years 1860–1870 and 1870–1880, but it in no way explains the remarkable run up in the observations which took place between 1870–1890.

The general tendency of the correction for personality is to introduce the suspicion of a periodical inequality, for which no adequate explanation can be

given. Thus while the discussion practically leaves the original discordances as puzzling as ever, it has removed what might justly have been considered as a possible explanation. It may be as well to mention here that on 1840 May 28 the object-glass of the Transit Instrument was separated, probably for the first time since it had been mounted, when it was found that the lenses were burnished together into their cell, and pressed together with so much force that the crown lens was a little splintered.

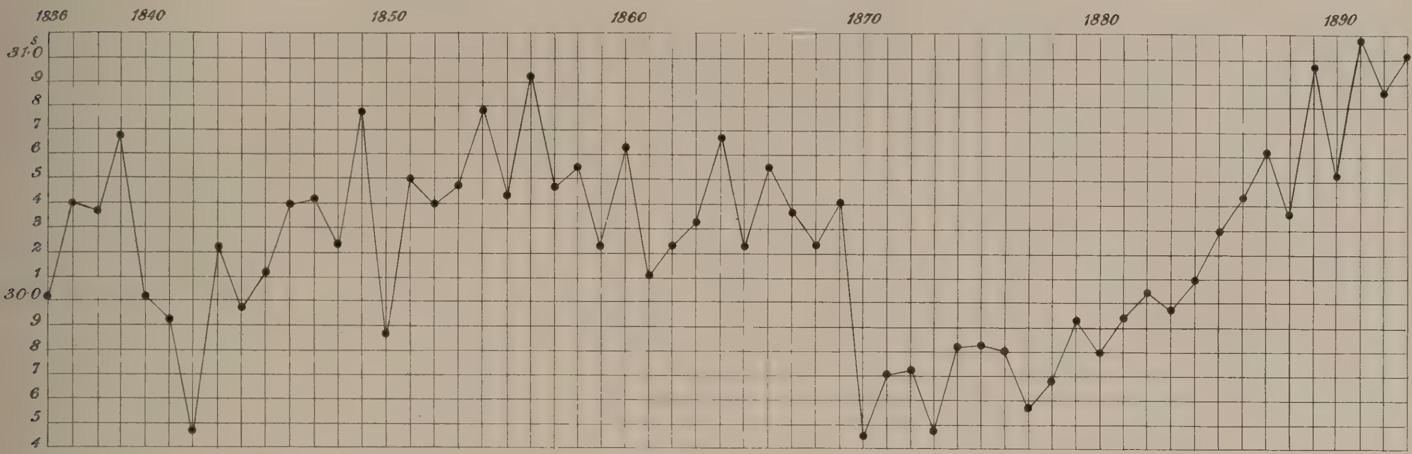
The North Polar Distances of Polaris.

We now come to the observations of North Polar Distance. For the years 1836–1839 these were made with the JONES and TROUGHTON Mural Circles, from 1840–1850 with the TROUGHTON Mural Circle, and from the year 1851 onwards with the Transit Circle. As the observations of *Polaris* and *Polaris* S. P. are made at nearly equal distances from the zenith, and are nearly equal in point of numbers, the annual mean place of *Polaris* may be considered as independent of any corrections for flexure or R−D, or of the adopted value of colatitude. For reducing the annual means to the selected epoch 1890 the precessions have been computed by CHAUVENET's formula.

The adopted P.M. in N.P.D. (derived from the observations) was $+0''\cdot005$. The years 1868–1874 have been corrected for errors in the microscope screws. All the observations have been reduced to the value of the colatitude $38^\circ\ 31'\ 21''\cdot90$, BESSEL's refractions, and correction for R−D $a+b \sin z$ and flexure $= 0''\cdot00$. For full information as to the reasons for adopting these corrections, reference should be made to Mr. CHRISTIE's paper on the "Greenwich North Polar Distances" (*Mem. R.A.S.*, vol. xlv.), and to Professor NEWCOMB's "Discussion of the Greenwich and Washington North Polar Distances," referred to above.

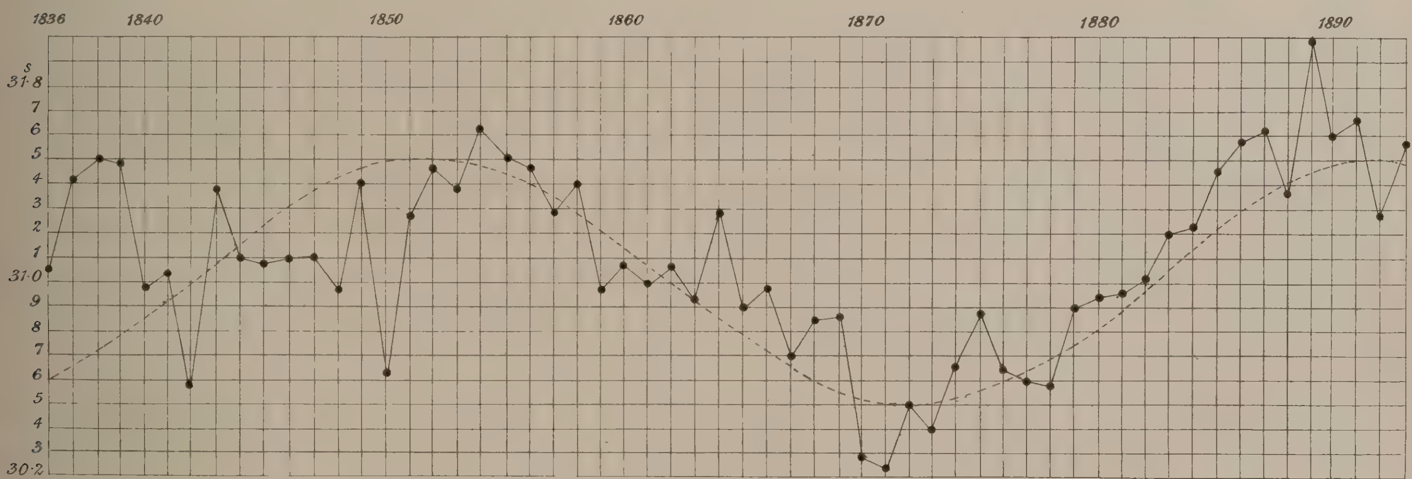
A

Observed Right Ascension of Polaris 1836-1893 reduced to 1890 by Chauvenet's formula and P. M + 0ˢ·1200 for the Epoch 1890 corrected to nutation 9″·147.



B

Right Ascension of Polaris 1836-1893 referred to "C" as standard reduced to 1890 by Chauvenet's formula and P. M + 0ˢ·1550 for the Epoch 1890 and corrected to nutation 9″·120.



The means of the results for 1846 and 1874 have been used in these diagrams.

C

North Polar Distances of Polaris for years 1836-1893 reduced to 1890 by Chauvenet's formula and adopted P. M. + 0″·005 for Epoch 1890.

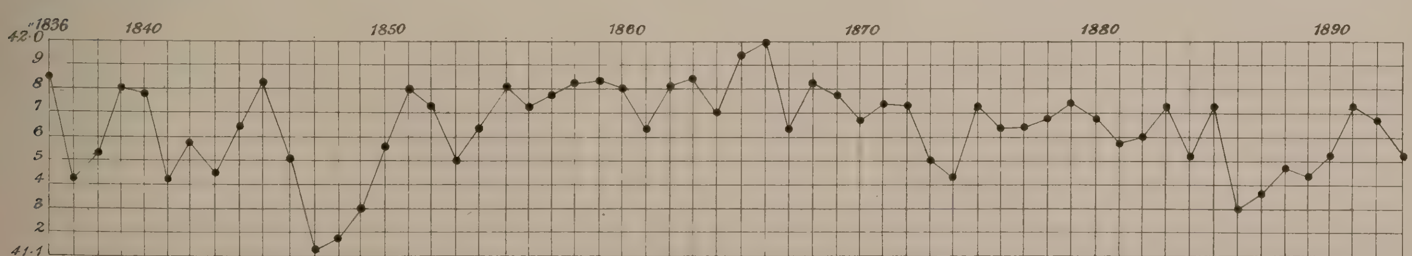


TABLE IX.

North Polar Distances of Polaris observed at Greenwich 1836–93, *reduced to* 1890 *by Peters' constants and adopted* P.M. $+0''\cdot005$.

Year.	Observed N.P.D.	Secs. of N.P.D. 1890·0 P.M. + 0″·005	Year.	Observed N.P.D.	Secs. of N.P.D. 1890·0 P.M. + 0″·005
	° ′ ″	″		° ′ ″	″
1836	1 33 55·34	41·85	1865	1 24 37·31	41·95
1837	35·56	41·43	1866	18·24	42·01
1838	16·34	41·54	1867	23 58·74	41·64
1839	32 57·27	41·81	1868	39·82	41·83
1840	37·92	41·77	1869	20·67	41·78
1841	18·24	41·41	1870	1·48	41·68
1842	31 59·12	41·58	1871	22 42·45	41·74
1843	39·66	41·46	1872	23·38	41·74
1844	20·57	41·64	1873	4·07	41·50
1845	1·46	41·84	1874	21 44·96	41·44
1846	30 41·86	41·51	1875	26·19	41·72
1847	22·17	41·13	1876	7·08	41·64
1848	2·98	41·18	1877	20 48·06	41·65
1849	29 43·83	41·31	1878	29·07	41·68
1850	24·84	41·56	1879	10·12	41·74
1851	5·80	41·78	1880	19 51·07	41·68
1852	28 46·52	41·74	1881	31·98	41·57
1853	27·04	41·50	1882	13·03	41·60
1854	7·96	41·64	1883	18 54·19	41·73
1855	27 48·90	41·81	1884	35·04	41·53
1856	29·62	41·74	1885	16·29	41·73
1857	10·44	41·77	1886	17 56·93	41·30
1858	26 51·33	41·84	1887	38·06	41·36
1859	32·15	41·85	1888	19·27	41·48
1860	12·93	41·80	1889	0·32	41·43
1861	25 53·60	41·64	1890	16 41·54	41·54
1862	34·62	41·82	1891	22·85	41·73
1863	15·47	41·85	1892	3·94	41·68
1864	24 56·19	41·69	1893	1 15 44·94	41·53

For diagram see Plate VII., curve C.

This latter paper also contains a discussion of the value of the constant of nutation, from which we extract the following convenient formula and table for correcting the nutation. Let

m=the constant of nutation
Ω=the longitude of the Moon's ascending node

then the apparent North Polar Distance of a star whose Right Ascension is α will be affected by the inequality

$$-\mathrm{N}\cos\Omega\sin\alpha+0{\cdot}745\,\mathrm{N}\sin\Omega\cos\alpha.$$

If then we determine the two quantities M and m from the equations

$$m\sin\mathrm{M}=0{\cdot}745\sin\Omega$$
$$m\cos\mathrm{M}=\cos\Omega$$

we have

$$\text{Nutation in North Polar Distance}=\mathrm{N}\,m\sin(\mathrm{M}-\alpha).$$

If we put ν for the correction to the adopted constant of nutation, the quantity $m\sin(\mathrm{M}-\alpha)$ will be the coefficient of ν in the apparent North Polar Distance of the star. The value of Ω has been taken for the middle of the year.

If then we arrange these annual means in periods of nineteen years, just the same as in the case of the Right Ascensions, give equal weights to each year's results, and put d'=the mean of each of the three determinations and d=the general mean, and ν the correction to the adopted constant of nutation ($9''{\cdot}233$), we shall get a series of equations of the form $m\sin(\mathrm{M}-d).\nu=d'-d$, the solution of which gives the value of the correction ν:

$$\nu=-0''{\cdot}072\pm0''{\cdot}027:$$

and the corresponding value of the nutation constant is $9''{\cdot}161\pm0''{\cdot}027$.

The values of $d'-d$ are given in Table X. and the solution of the equations by the method of least squares in Table XI.

Table X.

North Polar Distances of Polaris for the years 1836–1892, *reduced to* 1890 *by Chauvenet's formula and P.M.* +0″·005 *for the epoch* 1890, *arranged in* 19-*year periods.*

1836–1854	41″·85	41″·43	41″·54	41″·81	41″·77	41″·41	41″·58	41″·46	41″·64	41″·84	41″·51	41″·13	41″·18	41″·31	41″·56	41″·78	41″·74	41″·50	41″·64
1855–1873	41·81	41·74	41·77	41·84	41·85	41·80	41·64	41·82	41·85	41·69	41·95	42·01	41·64	41·83	41·78	41·68	41·74	41·74	41·50
1874–1892	41·44	41·72	41·64	41·65	41·68	41·74	41·68	41·57	41·60	41·73	41·53	41·73	41·30	41·36	41·48	41·43	41·54	41·73	41·68
d' =	41·70	41·63	41·65	41·77	41·76	41·65	41·63	41·62	41·69	41·75	41·66	41·63	41·37	41·50	41·61	41·63	41·67	41·66	41·61
d =	41·64																		
$d'-d$ =	+·06	−·01	+·01	+·13	+·12	+·01	−·01	−·02	+·05	+·11	+·02	−·01	−·27	−·14	−·03	−·01	+·03	+·02	−·03

Table XI.

Polaris N.P.D. Correction to Nutation Constant.

Year.	M − α.	Log sin (M − α).	Log *m*.	Log *m* sin (M − α).	*m* sin (M − α) = K.	$d'-d$.	K².	K ($d'-d$).	C − O.
1855	14°·8	+9·387	9·957	+9·344	+0·221	+0″·06	0·049	+0″·013	−0″·08
1856	358·20	−8·464	9·988	−8·452	−0·028	−0·01	·001	·000	+0·01
1857	343·22	−9·457	000	9·457	−0·287	+0·01	·082	− ·003	+0·01
1858	329·16	−9·708	9·990	9·698	−0·499	+0·13	·249	− ·065	−0·09
1859	313·1	−9·864	9·960	9·824	−0·667	+0·12	·445	− ·080	−0·07
1860	294·0	−9·961	9·918	9·879	−0·757	+0·01	·573	− ·008	+0·04
1861	271·1	0·000	9·881	9·881	−0·760	−0·01	·578	+ ·008	+0·07
1862	244·49	−9·957	9·874	9·831	−0·678	−0·02	·460	+ ·013	+0·07
1863	219·54	−9·807	9·901	9·708	−0·511	+0·05	·261	− ·025	−0·01
1864	199·49	−9·533	9·944	9·474	−0·298	+0·11	·089	− ·033	−0·09
1865	182·32	−8·645	9·981	−8·626	−0·042	+0·02	·002	− ·001	−0·02
1866	167·32	+9·334	9·999	+9·333	+0·215	−0·01	·046	− ·002	−0·01
1867	152·38	+9·662	9·996	9·658	+0·455	−0·27	·207	− ·123	+0·24
1868	137·18	+9·831	9·972	9·803	+0·635	−0·14	·403	− ·089	+0·09
1869	119·19	+9·940	9·932	9·872	+0·745	−0·03	·555	− ·022	−0·02
1870	97·21	+9·996	9·891	9·887	+0·771	−0·01	·594	− ·007	−0·05
1871	72·4	+9·978	9·872	9·850	+0·708	+0·03	·501	+ ·021	−0·08
1872	47·2	+9·864	9·890	9·754	+0·568	+0·02	·323	+ ·012	−0·06
1873	25·2	+9·626	9·930	+9·556	+0·360	−0·03	0·130	− ·011	+0·01
							5·548	−0·403	

$$\nu = -0''\cdot072 \pm 0''\cdot027$$

The corresponding value of the nutation constant is 9″·161 ± 0·027.

In conclusion, we may sum up the results of this discussion as follows :—

The deduced value of the proper motion in Right Ascension for the epoch 1890 $+0^{s}\cdot1200$ agrees well with Professor AUWERS' value of $+0^{s}\cdot1065$ for the epoch 1865, which by CHAUVENET'S formula (vol. i. p. 622) would be $+0^{s}\cdot1174$ for the epoch 1890. The difference between these values and $+0^{s}\cdot1550$, that determined from the observations when corrected for personality and referred to "C" as standard, is considerable. While there is no evidence to show that this latter value is due to secular change in "C," yet there is no evidence to show that it is the more likely value. That such a large difference should be indicated is somewhat surprising.

The values of the constant of nutation from

(1) The Right Ascensions of *Polaris* $9''\cdot147 \pm 0\cdot056$,
(2) The North Polar Distances of *Polaris* $9''\cdot161 \pm 0\cdot027$

agree closely together, and the mean of the two results $9''\cdot154$ is decidedly smaller than the usually adopted value of PETERS' $9''\cdot224$.

Further Measures of Double Stars made at the Temple Observatory, Rugby, during the Years 1890–1895. By G. M. SEABROKE and H. P. HIGHTON.

[Received June 14, 1895.]

THE following measures have been made during the past five years at the above-named observatory. The telescope used was the $8\frac{1}{4}$-inch equatorial with a bifilar micrometer, both of which have been described in the *Memoirs*, Vol. xlii., of the Society in connection with former measures.

All the measures have been made as before, with the head so held as to bring the line joining the eyes either parallel, or at right angles to the line joining the stars in process of measurement.

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+.	Observer.	Remarks.
				h m s	° ′	°		″				
48	318 B Cephei	13	6·6, 7·1	0 9 25	76 17	85·3	6	{est. 0·3}		90·11	H.	
283	24 Cassiopeiæ	60	4·0, 7·6	0 41 46	57 11	186·5	4	4·92	2	89·94	S.	
						186·7	4	5·10	2	·94	H.	
						192·4	4	5·14	2	91·14	H.	
						192·0	4	5·19	2	·14	H.	
						194·0	4	5·30	2	92·82	H.	
						202·5	4	5·30	2	93·93	S.	
						198·7	4	5·00	2	·93	H.	
						201·0	4	5·10	2	·94	H.	
						199·7	4	5·35	2	·94	S.	
319	36 Andromedæ	73	6·2, 6·8	0 48 32	22 58	14·1	4	1·20	2	·95	H.	
						12·2	5	1·40	1	·97	H.	Ill defined.
373		86	8·2, 8·7	0 58 43	− 6 6	157·2	4	14·50	2	·95	H.	B looks fainter than 8·7, ? 9·5.
515		125	7·9, 10·3	1 20 50	− 0 45	345·1	4	31·80	2	·95	H.	
637		158	8·3, 8·8	1 39 50	32 33	260·1	5	1·80	2	·95	H.	
677		175	8·2, 8·5	1 44 24	20 31	347·3	5	17·30	2	·97	H.	Dist. doubtful.
814	6 Trianguli	227	5·0, 6·4	2 5 25	29 44	74·7	4	4·20	2	·95	H.	
						76·3	6	3·90	2	·95	H.	
818	259 B Andromedæ	228	6·7, 7·6	2 6 21	46 55	221·5	1			89·94	H.	In contact.
										90·10	H.	Round.
										90·11	H.	In contact; failed to divide.
						209·0	1			91·14	H.	Not divided.
						232·0	2			·14	H.	Not divided.
						215·0	2			93·93	H.	Not divided.
						241·1	5			·94	S.	Elongated.
						237·1	3			·94	H.	
						240·3	3			94·13	S.	
						242·2	4			·13	S.	
826		232	7·5, 7·5	2 7 42	29 50	246·7	5	7·30	2	93·95	H.	

						247·8	4	7·00	2	·95	H.	
875	o Ceti		2·5, 9·5	2 13 17	− 3 32	80·2	4	109 84	2	89·86	H.	
1084		328	8·5, 9·0	2 49 48	44 2	300 4	4	23·00	2	93·95	H.	
1188		[53]	7·0, 8·0	3 9 53	38 11	256·5	2	1·00	2	89 86	H.	
1343		[61]	7·0, 10·0	3 36 20	7 31					·86	H.	Cou'd not divide, or failed to find it. If anything.
1392		[65]	6·5, 6·5	3 43 6	25 13	168·0				·86		
1406	49 Cephei	460	5 2, 6·1	3 49 56	80 22	46·8	4	1·45	2	94·13	S.	
						45·2	4	1·27	2	·13	H.	
1494		3114	8·0, 10·5	4 0 37	39 49	169·2	4	1·60	1	·13	S.	
						169·0	3	1·60	1	·13	H.	
						170·6	4	1·67	2	·18	S.	
1521		[74]	8·0, 8·5	4 6 22	9 20	0·5	1			89·86	H.	Not divided.
1528		511	7·5, 8·0	4 7 51	58 29	270·8	1	(est. 0·5)		94·13	S.	
						267·3	4	(est. 0·4)		·13	H.	
						272·2	3	(est. 0·5)		·16	S.	
1602		[82]	7·0, 9 0	4 16 55	14 46						H.	Failed to divide.
1592		531	7·4, 8·6	4 17 4	55 22	306·0	4	1·00	2	·16	S.	
						300·5	4	0·95	2	·18	S.	
						306·2	5	1·10	1	·19	H.	
1631		547	8·0, 11·0	4 19 55	− 1 40					89·86		Failed; too bright; moonlight.
		589	8·0, 8·0	4 38 26	5 4	299·7	4	4·60	2	94·16	S.	
						299·3	4	4·40	2	·18	S.	
1947		651	8·0, 10·0	5 4 3	− 7 12	50·5	4	19·10	2	89·93	H.	
						54·5	4	19·07	2	90·10	H.	
						52·1	4	19·47	2	·10	H.	
						50·1	4	19·90	2	91·14	H.	
						48·5	2			·14	H.	Too faint for distance.
						49·1	4	19·20	1	93·93	H.	
						49·5	3	20·10	2	94·13	S.	
						48·8	4	20·07	2	·13	S.	
1991	λ Aurigæ		5·4, 8·2	5 10 35	40 0	9·8	4	132·70	3	·18	S.	
2384		826	8·5, 9·2	5 52 49	− 1 20	157·1	2			·20	S.	

Herschel's Number.	Name of Star.		Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1880 +.	Observer.	Remarks.
					h m s	° ′	°						
2384			826	8·5, 9·2	5 52 49	− 1 20	156·4	2			·20	H.	
2462			853	7·5, 8·5	6 2 30	11 41	352·8	3	28·60	2	·20	S.	
							351·0	4	28·20	2	·20	H.	
3228	Castor		1110	2·7, 3·7	7 26 57	32 9	226·1	4	6·07	2	90·10	H.	
							228·4	4	5·84	2	·10	H.	
							230·9	4	6·04	2	·11	H.	
							230·7	4	7·13	2	·18	H.	
							229·6	4	5·50	2	·19	H.	
							234·7	4	6·10	2	91·14	H.	
							234·2	4	5·80	2	·14	H.	
							232·1	4	5·90	2	·21	H.	
							227·7	6	5·90	2	92·82	H.	Very hazy; no def.
							228·2	4	6·30	2	93·21	H.	
							228·9	4	6·60	2	·23	H.	
							228·5	4	6·10	2	·23	H.	
							227·3	4	6·00	2	·93	H.	
							228·4	4	5·80	2	·95	H.	
3557	ζ Cancri	AB	1196	{5·0 / 5·7, 5·5}	8 5 11	18 0	39·0	4	1·05	2	90·10	H.	
		AB					41·7	4			·11	H.	Too hazy for dist.
		AB					40·3	4	1·04	2	·18	H.	
		AB					37·9	4	0·90	2	91·14	H.	
		AB					36·5	4	0·81	2	·14	H.	
		AB					28·3	4	0·82	2	93·21	H.	
		AB					28·9	4	0·80	2	·23	H.	
		AB					29·6	4			·23	H.	
		AC					117·7	4	5·90	2	89·93	H.	
		AC					116·8	4	5·90	2	90·10	H.	
		AC					119·0	4	5·74	3	·11	H.	
		AC					116·5	4	6·17	2	·18	H.	

	AC					115·2	4	5·60	2	91·14	H.	
	AC					117·5	4	5·40	2	·14	H.	
	AC					115·7	4	5·00	2	93·21	H.	
	AC					115·0	4	5·50	2	·23	H.	
4083		3121	7·5, 7·8	9 10 43	29 8	55·5	2			90·18	H.	
						55·0	1			·19	H.	Not divided; very doubtful.
4084		1333	6·5, 6·5	9 11 2	35 52	44·6	4	1·30	2	90·19	H.	
4165	ω Leonis	1356	6·2, 7·0	9 22 1	9 34	93·0	2			·18		Very doubtful; not divided.
						104·7	4	0·50	1	91·14	H.	Distinctly divided.
						107·0	2	{est. 0·5}		·21	H.	Very shaky.
						102·2	4	0·8	2	·35	H.	
						105·0	4	{est. 0·5}		93·21	H.	
						104·7	4	{est. 0·4}		·23	H.	Unsteady.
4290	φ Ursæ Maj.		5·0, 5·6	9 43 57	54 37	334·0	2			90·19	H.	Not divided; very doubtful.
4314	8 Sextantis		6·0, 6·5	9 46 34	− 7 32	94·5	2			·18	H.	Not divided; very doubtful.
						89·2	2			91·35	H.	Not divided.
						176·2	2			93·21	H.	Not divided.
4497			7·5, 7·5	10 18 25	53 14	82·6	4	4·10	2	90·19	H.	
4860	ξ Ursæ Maj.	1523	4·0, 4·9	11 11 48	32 12	212·8	4	2·05	2	·18	H.	
						210·0	4	1·40	2	·19	H.	
						211·7	4	1·50	2	·20	H.	
						201·2	4	1·20	2	91·21	H.	
						198·9	4	1·50	2	·35	H.	
						198·4	4	2·00	2	·35	H.	
						193·7	4	1·20	2	92·37	H.	Dist. uncertain.
						195·6	4	1·30	2	·39	H.	
						194·6	4	1·40	2	·39	H.	
						186·0	4	1·60	2	93·21	H.	
						190·8	5	1·15	2	·23	H.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+.	Observer.	Remarks.
4860	ξ Ursæ Maj.	1523	4·0, 4·9	h m s 11 11 48	° ′ 52 12	° 190·4	4	″ 1·70	2	·23	H.	
						189·7	5			·23	H.	
5639	P. XIII. 127 Virginis		7·8, 8·9	13 28 10	0 18	79·0	2			90·19	H.	Too indistinct for dist.
5754		1785	7·2, 7·5	13 43 38	27 34	238·6	4	1·30	2	90·19	H.	
						236·5	4	1·05	2	·20	H.	
						243·1	4	1·37	2	·38	H.	
						243·0	2			91·21	H.	Too blurred for reliable measures.
						246·0	4	1·64	2	·35	H.	
						248·2	4	1·41	2	·44	H.	
						246·4	4	1·28	2	92·37	H.	
						249·1	4			·39	H.	Ill-defined; hazy.
						249·8	4	1·00	2	·40	H.	
						253·4	4			93·35	H.	
						251·6	4	1·07		·39	H.	
5907		1819	7·9, 8·0	14 9 18	3 41	6·9	4	1·26	2	90·38	H.	
						7·4	4	1·46	2	·38	H.	
						8·5	4	(est.) 1·0		91·35	H.	
						6·5	4	0·85	2	·44	H.	
						5·1	4	0·60	2	92·37	H.	
						5·1	4			·40	H.	
						6·2	4	1·20	2	93·39	H.	Distance high.
6146	ξ Bootis	1888	4·7, 6·6	14 45 51	19 35	243·4	4	2·46	2	90·20	H.	
						246·0	4	3·96	2	·38	H.	
						246·2	4	3·93	2	·38	H.	
						246·0	4	3·87	2	91·41	H.	
						245·4	4	3·44	2	·44	H.	
						246·4	4	3·21	2	·45	H.	
						237·9	4	3·41	2	92·37	H.	
						237·8	4	3·13	2	·40	H.	

							240·6	4	2·47	2	·44	H.	
							233·8	4	3·61	2	93·39	H.	
							232·1	4	3·60	2	94·47	H.	
							232·4	4	3·20	2	·50	S.	
							232·7	4	2·90	2	·50	H.	
6159				8 5, 7·5	14 47 6	45 25	323·5	2			91·48	H.	Too hazy for dist. reading.
6362	η Coronæ		1937	5·2, 5·7	15 18 14	30 43	180·0	2			90·38	H.	Not divided.
							221·2	5			91·44	H.	Appeared to be divided at times.
							217·5	1			·44	S.	
							230·2	4			92·40	H.	Not divided; elongated only.
							268·6	2			94·47	H.	
							268·6	3			·47	S.	
6371	μ^2 Boötis		1938	6·7, 7·3	15 19 59	37 46	98·2	4	0·89	2	90·38	H.	
							101·3	3	{est. 0·5}		·52	H.	
							95·0	4	{est. 0·5}		·53	H.	Distinctly divided.
							111·1	2			91·41	H.	Doubtful; no definition.
							94·0	4	0·60		·44	H.	
							87·8	4	{est. 0·5}		92·43	H.	
							91·0	4	{est. 0·3}		·44	H.	Very unsteady.
							87·1	4	0·92	2	94·46	S.	
							86·9	4	0·87	2	·46	H.	
6469	γ Cor. Bor.		1967	4·0, 7·0	15 37 43	26 40	232·0	2			91·44	H.	Very doubtful, not divided.
							244·5	1			92·43	H.	Unsteady; seemed divided at times.
							275·2	3			94·46	H.	
							280·3	2			·46	S.	
6582	ξ Scorpii	AB	1998	4·9, 5·2, 7·2	15 57 46	— 11 2	195·7	2	{est. 0·8:}		90·39	H.	Too blurred for distinct reading.
		AB					206·1	4	0·85	2	·52	H.	
		AB					198·0	2			91·45	H.	Too blurred for distinct reading.

Herschel's Number.	Name of Star.		Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+.	Observer.	Remarks.
					h m s	° ′	°		″				
6582	ξ Scorpii	AB	1998	4·9 5·2, 7·2	15 57 46	− 11 2	210·3	3	{est. 0·8}		92·43	H.	
		AB					215·0	4	1·30	2	94·46	S.	
		AB					211·8	4	1·00	2	·46	H.	
		AC					70·0	4	6·20	2	90·39	H.	
		AC					69·0	4	7·50	2	·52	H.	
		AC					71·2	4	6·04	2	91·45	H.	
		AC					66·8	4	6·70	2	92·43	H.	
		AC					69·0	4	6·20	2[1]	94·46	S.	
		AC					69·0	4	6·53	2	·46	H.	
6654	σ Coronæ	AB		5·0, 6·1	16 10 12	34 9	209·0	4	5·30	2	91·48	H.	
							210·2	4	4·40	2	94·49	H.	
							210·8	4	4·60	2	·50	H.	
							211·4	4	4·20	2	·50	S.	
6707	Antares, α Scorpii			1·5, 7·7	16 22 3	− 26 9					91·48	H.	Could not see companion.
							285·1	1			94·50	S.	
							283·6	1			·50	H.	
6727	λ Ophiuchi		2055	4·0, 6·1	16 24 52	2 14	48·5	4	1·10	2	90·52	H.	Very shaky.
							47·7	4	1·20	2	·53	H.	
							49·7	4	1·07	2	·56	H.	
							55·5	4	1·10	2	91·45	H.	
							49·7	4	1·05	2	·45	H.	
							49·5	4	1·02	2	·46	H.	
							50·4	4	0·60	2	92·43	H.	
							51·0	4			94·84	H.	Low down, elongated into spectra.
6799	ζ Herculis		2084	3·0, 6·5	16 36 48	31 48	74·7	4	0·80	2	90·53	H.	
							69·7	2			·56	H.	Too blurred for distance reading.
							59·0	4	0·85	2	91·45	H.	
							50·5	2			94·78	S. and H.	
							53·5	6			·84	H.	Just divided.

6840	21 Ophiuchi	[315]	6·2, 8·1	16 45 20	1 25	165·5	4			·49	H.	Barely divided.
						158·1	4	1·20	2	·50	S.	
						156·8	4	0·90	2	·50	H.	
6847	Herculis 167 B	2107	6·5, 8·0	16 47 6	28 52	287·5	1			·77	S.	
6946	36 Ophiuchi		4·5, 6·5	17 8 0	− 26 25	192·7	4	4·60	2	·49	H.	
6968	δ Herculis	3127	3·0, 8·1	17 10 6	24 58	185·1	4	15·70	2	90·53	H.	
						188·4	4	16·50	2	·55	H.	
7245	τ Ophiuchi	2262	5·0, 5·7	17 56 33	− 8 10	254·5	4	1·90	2	94·49	H.	
						254·2	4	2·00	2	·50	H.	
						255·8	4	1·90	2	·50	S.	
7273	70 Ophiuchi	2272	4·1, 6·1	17 59 23	2 32	335·8	4	2·10	2	90·52	H.	
						339·5	4	2·58	2	·53	H.	
						340·7	4	3·15	2	·56	H.	
						332·4	4	2·34	2	91·46	H.	
						330·0	4	2·67	2	·48	H.	
						303·7	4	2·50	2	94·50	S.	
						306·4	4	2·72	2	·50	H.	
						303·8	4	2·25	2	·77	S.	
						302·0	4	2·56	2	·77	H.	
7322	Herculis 417 B		6·0, 7·1	18 4 47	16 27	233·7	4	1·05	2	90·53	H.	
						234·6	4	0·91	2	·55	H.	
						231·1	4	1·42	2	94·80	S.	
						231·1	3	1·48	2	·80	H.	
	β 641		7·5, 9·0	18 17	21 27	357·5	4	0·62	2	92·81	H.	
						358·4	4			94·77	S.	
						355·0	2			·77	H.	
7753		2455	7·2, 8·3	19 1 44	21 59	90·5	4	2·72	2	94·80	S.	
						86·8	4	4·34	2	·80	H.	
7835		2488	8·5, 9·7	19 10 15	19 49						H.	Failed to divide.
8386		2640	6·0, 9·9	20 3 14	63 32	17·9	4	5·75	2	·80	S.	
						20·9	4	5·52	2	·80	H.	
						22·0	4	5·55	2	94·84	S.	
						21·8	4	5·40	2	·84	H.	

Herschel's Number.	Name of Star.	Struve's Number.	Mags.	R.A. 1880.	Dec. 1880.	Position Angle.	No. of Obs.	Distance.	No. of Obs.	Date 1800+.	Observer.	Remarks.
				h m s	° ′	°		″				
8784	4 Aquarii	2729	5·9, 7·2	20 45 3	− 6 5	197·0	2			92·83	H.	Cannot divide.
						139·2	4			94·84	H.	Doubtful.
8811		[416]	7·8, 8·1	20 47 43	43 18	139·4	4	7·80	2	90·55	H.	
						134·2	4	7·11	2	94·80	S.	
						132·1	4	8·08	2	·80	H.	
						134·3	4	8·12	2	·84	H.	
						135·0	4	7·42	2	·84	S.	
8898	61 Cygni		5·3, 5·9	21 1 13	38 6	122·5	4	20·50	2	90·56	H.	
						123·5	4	22·80	2	92·81	H.	
						122·6	4	22·15	2	·82	H.	
						123·6	4	22·60	2	·83	H.	
						122·4	4	21·70	2	·90	H.	
						122·6	4	21·50	3	93·93	S.	
						123·0	4	22·40	2	·93	H.	
						122·5	4	21·50	2	93·95	H.	
						123·1	6	21·70	2	94·84	H.	
						122·9	2	21·70	2	·91	H.	
								21·00	3	·91	S.	
9072	Pegasi 20 B	2799	6·5, 7·4	21 23 2	10 33	304·1	4	1·10	2	90·55	H.	
9930	π Cephei	[489]	5·2, 7·5	23 4 4	74 41	38·5	4	1·22	2	94·91	S.	
10304	B.A.C. 8372	3062	6·9, 8·0	23 59 57	57 46	324·2	4	1·51	2	90·10	H.	
						322·5	4	1·37	2	·11	H.	
						324·5	4	1·20	2	91·14	H.	
						327·7	4	1·27	2	92·82	H.	
						329·4	4	1·50	2	93·93	H.	
						331·1	4	1·07	2	93·93	S.	
						329·1	4	1·60	2	·94	S.	
						332·9	4	1·70	2	94·91	S.	
						330·6	4	1·62	2	·91	H.	

A LIST OF PERSONS

TO WHOM

THE MEDALS OR TESTIMONIALS OF THE SOCIETY

HAVE BEEN ADJUDGED.

1823.

June 13. CHARLES BABBAGE, Esq.

The Gold Medal.—For his Invention of an Engine for computing and printing Mathematical Tables.

Professor JOHANN FRIEDRICH ENCKE.

The Gold Medal.—For his Investigations relative to the Comet which bears his name.

CHARLES RUMKER, Esq.

The Silver Medal.—For his Rediscovery of ENCKE'S Comet in 1822.

M. JEAN LOUIS PONS.

The Silver Medal.—For his Discovery of Two Comets in 1822.

1826.

Feb. 7. J. F. W. HERSCHEL, Esq., and JAMES SOUTH, Esq.

The Gold Medal, each.—For their important Researches on the subject of Multiple Stars.

Feb. 10. Professor STRUVE.

The Gold Medal.—For his important Researches on the subject of Multiple Stars.

1827.

Feb. 2. FRANCIS BAILY, Esq.

The Gold Medal.—For his "New Tables for determining the places of 2,881 Stars."

WILLIAM SAMUEL STRATFORD, Esq.

The Silver Medal.—For his Superintendence of the Computation of "New Tables for determining the places of 2,881 stars."

1827.
Feb. 5. Colonel Mark Beaufoy.
The Silver Medal.—For his valuable Collection of Observations, particularly those of the Eclipses of *Jupiter's* Satellites.

1828.
Jan. 11. Sir Thomas Macdougall Brisbane, K.C.B.
The Gold Medal.—For his Establishment of an Observatory, and for an important series of Observations made at Paramatta.

James Dunlop, Esq.
The Gold Medal.—For his Observations of the Nebulæ of the Southern Hemisphere.

Feb. 4. Miss Caroline Herschel.
The Gold Medal.—For her recent reduction, to January 1800, of the Nebulæ discovered by Sir William Herschel.

1829.
Jan. 9. Rev. William Pearson.
The Gold Medal.—For his work entitled "An Introduction to Practical Astronomy."

Professor Bessel.
The Gold Medal.—For his Zone Observations.

Professor Schumacher.
The Gold Medal.—For the publication of his various Astronomical Tables, and the "Astronomische Nachrichten."

1830.
Jan. 8. Mr. William Richardson.
The Gold Medal.—For his Investigation of the Constant of Aberration.

Professor Encke.
The Gold Medal.—For the New Berlin Ephemeris.

1831.
Jan. 14. Captain Kater.
The Gold Medal.—For his Invention of the Vertical Floating Collimator.

Baron Damoiseau.
The Gold Medal.—For his Memoir upon the Theory of the Moon, and for his Lunar Tables.

1833.
Jan. 11. Professor Airy.
The Gold Medal.—For his Discovery of the long Inequality of *Venus* and the Earth.

1835.
Jan. 9. Lieutenant JOHNSON.
The Gold Medal.—For his Catalogue of 606 Southern Stars.

1836.
Jan. 8. Sir JOHN F. W. HERSCHEL.
The Gold Medal.—For his Catalogue of Nebulæ, printed in the "Philosophical Transactions" for 1833.

1837.
Jan. 13. Professor ROSENBERGER.
The Gold Medal.—For his Investigations relative of HALLEY'S Comet.

1839.
Jan. 11. Hon. JOHN WROTTESLEY.
The Gold Medal.—For his Catalogue of the Right Ascensions of 1,318 Stars.

1840.
Jan. 10. M. JEAN PLANA.
The Gold Medal.—For his Work, entitled "Théorie du Mouvement de la Lune."

1841.
Jan. 8. Professor BESSEL.
The Gold Medal.—For his Observations and Researches on the Parallax of 61 *Cygni*.

1842.
Jan. 14. M. HANSEN.
The Gold Medal.—For his Researches in Physical Astronomy.

1843.
Jan. 13. FRANCIS BAILY, Esq.
The Gold Medal.—For his Experiments to determine the Mean Density of the Earth in repetition of what is generally termed the "Cavendish Experiment."

1845.
Jan. 10. Captain WILLIAM HENRY SMYTH, R.N.
The Gold Medal.—For his "Bedford Catalogue," forming the second part of his work entitled "Celestial Cycle."

1846.
Jan. 9. GEORGE BIDDELL AIRY, Esq., Astronomer Royal.
The Gold Medal.—For his Reduction of the Observations of Planets made at the Royal Observatory, Greenwich, from 1750 to 1830.

1848. *Testimonials were awarded to*

Jan. 14. George Biddell Airy, Esq., Astronomer Royal.
For the Lunar Reductions recently made at Greenwich.

John Couch Adams, Esq.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Professor Argelander.
For his Catalogue of Stars.

George Bishop, Esq.
For the Foundation of an Observatory leading to various Astronomical Discoveries.

Lieut.-Col. George Everest.
For his Measurement of the Indian Arc.

Sir John F. W. Herschel.
For his Work on the Southern Hemisphere.

Professor P. A. Hansen.
For his Lunar Theory and Computation of Perturbations.

M. Hencke.
For his Discovery of two Planets, *Astræa* and *Hebe*.

John Russell Hind, Esq.
For his Discovery of two Planets, *Iris* and *Flora*.

M. Le Verrier.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Sir John Lubbock.
For his Researches in the Theory of Perturbations.

M. M. Weisse.
For his Catalogue of Stars in Bessel's Zones.

1849.
Feb. 9. William Lassell, Esq.
The Gold Medal.—For the construction of his Equatorial Instrument and for the Discoveries made with it.

1850.
Feb. 8. M. Otto von Struve.
The Gold Medal.—For his Paper on the Constant of Precession.

1851.
Feb. 15. Dr. ANNIBALE DE GASPARIS.
The Gold Medal.—For the Discovery of three Planets, *Hygeia*, *Parthenope*, and *Egeria*.

1852.
Feb. 13. Dr. C. A. F. PETERS.
The Gold Medal.—For his Papers on the Parallax of the Fixed Stars, and on the Constant of Nutation.

1853.
Feb. 11. JOHN RUSSELL HIND, Esq.
The Gold Medal.—For the Discovery of eight Planets, and other Astronomical Discoveries.

1854.
Feb. 10. M. CHARLES RUMKER.
The Gold Medal.—For his Catalogue of 12,000 Stars, and for other Astronomical Services.

1855.
Feb. 9. Rev. W. R. DAWES.
The Gold Medal.—For his Astronomical Labours generally.

1856.
Feb. 8. ROBERT GRANT, Esq.
The Gold Medal.—For his "History of Physical Astronomy."

1857.
Feb. 13. M. SCHWABE.
The Gold Medal.—For his Discovery of the Periodicity of the Solar Spots.

1858.
Feb. 12. Rev. ROBERT MAIN.
The Gold Medal.—For his various Contributions to the *Memoirs* of the Society.

1859.
Feb. 11. R. C. CARRINGTON, Esq.
The Gold Medal.—For his "Redhill Catalogue of 3,735 Circumpolar Stars."

1860.
Feb. 10. Professor P. A. HANSEN.
The Gold Medal.—For his Lunar Tables.

1861.
Feb. 8. M. HERMANN GOLDSCHMIDT.
The Gold Medal.—For his Discovery of thirteen of the Minor Planets, and other Astronomical Discoveries.

1862.
Feb. 14. WARREN DE LA RUE, Esq.
The Gold Medal.—For his Astronomical Researches, and especially for his Application of Photography.

1863.
Feb. 13. Professor ARGELANDER.
The Gold Medal.—For his Survey of the Northern Heavens.

1865.
Feb. 10. Professor G. P. BOND.
The Gold Medal.—For his work on the Comet of DONATI, and other Astronomical Researches.

1866.
Feb. 9. Professor ADAMS.
The Gold Medal.—For his Contributions to the Development of the Lunar Theory.

1867.
Feb. 8. W. HUGGINS, Esq., and Professor MILLER.
The Gold Medal.—For their Researches in Astronomical Physics.

1868.
Feb. 14. M. LE VERRIER.
The Gold Medal.—For his Planetary Tables.

1869.
Feb. 12. E. J. STONE, Esq.
The Gold Medal.—For his Rediscussion of the Transit of *Venus* in 1769, and his other contributions to Astronomy.

1870.
Feb. 11. M. DELAUNAY.
The Gold Medal.—For his "Théorie de la Lune."

1872.
Feb. 9. Signor SCHIAPARELLI.
The Gold Medal.—For his Researches on the Connexion between the Orbits of Comets and Meteors.

1874.
Feb. 13. Professor SIMON NEWCOMB.
The Gold Medal.—For his Tables of *Neptune* and *Uranus*, and other contributions to Mathematical Astronomy.

1875.
Feb. 12. Professor D'ARREST.
The Gold Medal.—For his work entitled "Siderum Nebulosorum Observationes Havnienses, institutæ in Specula Universitatis per tubum sedecimpedalem Merzianum, ab anno 1861 ad annum 1867," and other Astronomical Works.

1876.
Feb. 11. M. Le Verrier.
The Gold Medal.—For his Investigations of the Theories of *Jupiter*, *Saturn*, *Uranus*, and *Neptune*, and for his Tables of *Jupiter* and *Saturn*.

1878.
Feb. 8. Baron Dembowski.
The Gold Medal.—For his Researches on Double Stars.

1879.
Feb. 14. Professor Asaph Hall.
The Gold Medal.—For his Discovery and Observations of the Satellites of Mars, and for his Determination of their Orbits.

1881.
Feb. 11. Professor Axel Möller.
The Gold Medal.—For his Investigations of the Motion of Faye's Comet.

1882.
Feb. 10. David Gill, Esq.
The Gold Medal.—For his Heliometer Observations of *Mars* at Ascension, and for his Discussion of the Results.

1883.
Feb. 9. Dr. B. A. Gould.
The Gold Medal.—For his *Uranometria Argentina.*

1884.
Feb. 8. A. A. Common, Esq.
The Gold Medal.—For his Photographs of Celestial Bodies.

1885.
Feb. 13. Dr. W. Huggins.
The Gold Medal.—For his Researches on the Motions of Stars in the Line of Sight, and on the Photographic Spectra of Stars and Comets.

1886.
Feb. 12. Professor E. C. Pickering and Professor Charles Pritchard.
The Gold Medal, each.—For their Photometric Researches.

1887.
Feb. 11. G. W. Hill, Esq.
The Gold Medal.—For his Researches on the Lunar Theory.

1888.
Feb. 10. Professor Arthur Auwers.
The Gold Medal.—For his Re-reduction of Bradley's Observations.

1889.
Feb. 8. M. Maurice Lœwy.

The Gold Medal.—For his Equatorial Coudé, his Method of Determining the Constant of Aberration, and his other Astronomical Researches.

1892.
Feb. 12. Professor G. H. Darwin.

The Gold Medal.—For his work on the Tides and their Influence on the Figures and Motions of the Heavenly Bodies.

1893.
Feb. 10. Professor H. C. Vogel.

The Gold Medal.—For his Spectroscopic and other Astronomical Observations.

1894.
Feb. 9. Professor S. W. Burnham.

The Gold Medal.—For his Discoveries and Measurements of Double Stars.

1895.
Feb. 8. Dr. Isaac Roberts.

The Gold Medal.—For his Photographs of Star Clusters and Nebulæ.

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1899

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OBSERVATIONS

OF

TWENTY-THREE VARIABLE STARS

BY THE LATE

GEORGE KNOTT

EDITED BY

H. H. TURNER, M.A., F.R.S.

SAVILIAN PROFESSOR OF ASTRONOMY IN THE UNIVERSITY OF OXFORD

LONDON

ROYAL ASTRONOMICAL SOCIETY

BURLINGTON HOUSE

1899

Observations of Variable Stars. By GEORGE KNOTT.

Introductory Note. **By H. H. TURNER, F.R.S., Sec. R.A.S., Savilian Professor.**

THE observations of variable stars contained in this volume were made by the late GEORGE KNOTT, F.R.A.S., at Cuckfield, in Sussex, during the years 1860 to 1894. The earliest observation (of *U Geminorum*) is dated 1860 December 14, and the latest, 1894 January 31. Shortly after Mr. KNOTT's death, on 1894 October 8, his relatives consulted me, as Secretary of this Society, on the steps to be taken for publishing these observations ; and Mrs. KNOTT signified her desire to contribute in a generous manner towards the publication (see *Monthly Notices*, lv. 195–7). On examining the records I found that Mr. KNOTT had entered his observations regularly in ledgers in such a way that the material could be placed almost directly in the printer's hands unless it was considered advisable from motives of economy to condense it. On this point I wrote to Mr. S. C. CHANDLER, sending him a copy of one of the ledgers, and asking for the guidance of his experience in discussing observations of variables for the formation of his well-known catalogues ; and he kindly replied, at some length, strongly urging the publication of the observations in full. This course was accordingly sanctioned by the Council.

EDITING OF THE MS.—It did not seem necessary to invite the assistance of a special Editor, as Mr. KNOTT had practically made the copy for press himself, and the proof reading would necessarily be done by the Secretaries and Assistant Secretary in their capacity of Editors of the Society's publications. That the material had not been sent to press earlier was probably

merely because no specially appropriate occasion had presented itself. When Mr. Knott changed his residence (1873–75) from Woodcroft to Knowles Lodge he occupied the months during which his telescope was dismounted in passing through the press his observations of double stars (*Memoirs R.A.S.*, vol. xliii.; see also *Monthly Notices*, lv. 195), and he did not afterwards resume this branch of work. No similar opportunity occurred during his life-time for publishing the variable star observations.

Instrument.—Mr. Knott's telescope was a $7\frac{1}{3}$-inch equatorial by Alvan Clark, obtained through the Rev. W. R. Dawes in 1859.

Method of Observing.—Of his method of observing he has left a clear account in a small pamphlet[1] which need not be here produced in full, but some parts of which are significant. The pamphlet opens with some historical remarks about star magnitudes and an explanation of the formula

$$l = L + 5 \times \text{log aperture (in inches)},$$

where l is the magnitude of a star which is "just discernible by fits" with the given aperture, and L that of a star similarly discernible with an aperture of one inch. [It will be seen that in this formula Pogson's light-ratio is adopted.] The magnitudes of comparison stars were apparently determined by Mr. Knott in this way, about which it is needless to say more.

Being then furnished with a chart of the neighbourhood of the variable with comparison stars of known magnitudes, the "observer compares the variable with two or more stars on his list, which differ least from it in brightness, and carefully estimates the differences in tenths of a magnitude, *being guided in his estimations by reference to the known differences of the comparison stars.* He thus obtains several *more or less independent* values for the magnitude of the variable," &c.

The italics, which are mine, draw attention to the precise method of observing. It seems clear that Mr. Knott did not aim at an independent assessment of a tenth of a magnitude, but was throughout "guided by references to the known differences of the comparison stars." If any confirmation is needed of this very clear statement, it is afforded by the case of *S Aquilæ*. On page 237 it will be seen that a change is made in the adopted magnitudes of some of the comparison stars on 1885 May 20: the magnitudes

[1] *On the Method of Observing Variable Stars.* By George Knott, LL B. Lond., F.R.A.S., and Joseph Baxendell, F.R.A.S., &c. London, 1863. Printed for private circulation.

of a and b are unchanged, but the magnitude of c is changed from 10·1 to 9·8, and of d from 10·4 to 10·1. Now, on 1884 December 9, Mr. Knott records for the variable

$a+8$ $c-1$ equivalent to 10·0 10·0

but on 1885 August 10 he records

$a+3$ $c-3$ equivalent to 9·5 9·5

It seems clear that the $a+8$ of the former date is not an independent estimate, but is to be combined with the $c-1$ observation; and that if we correct the observations previous to 1885 May 20, so as to accord with those made after that date, we must write for 1884 December 9

$a+5$ $c-1$ equivalent to 9·7 9·7

and *not*

$a+8$ $c-1$ „ „ 10·0 9·7

Thus, although no change was made in the adopted magnitude of a (and b), we shall have to correct the observations depending on a and b because of the changes made in c and d; and it becomes a question how to correct observations depending on a alone, such as the $a-3$ and $a-4$ of 1869 January 15 and 17. The difficulty is not a serious one, the cases of doubt being rare and unimportant; but I have thought it better to leave the correction to be made by anyone who hereafter discusses the observations rather than adopt a procedure open to criticism.

In connection with Mr. Knott's habits of observation, it may be remarked that he was in constant correspondence with the Baxendells, father and son; and telegrams or letters were sent from one observer to the other announcing any unexpected change in brightness, especially in the irregular variables, of which the most conspicuous is *U Geminorum*. Sometimes these telegrams crossed, as when Mr. Knott wrote to Mr. Baxendell, Jun., on 1892 January 25: "I was greatly amused at receiving your telegram this morning, about half-an-hour after I had started one to you and one to Espin respecting our friend *U Geminorum*." Thus the observer occasionally went to the telescope expecting a change in the variable; and though it is unlikely that this would influence the observations seriously, it is a fact to be remembered.

Mr. Knott accordingly entered in the "Remarks" column some phrase such as "Observed in consequence of a telegram from Mr. Baxendell."

Notation.—Returning to the pamphlet, it next calls attention to the ambiguity running through the terms "greater than," "less than," +, −, > or < in comparing star-magnitudes, saying that "it must be left to the observer to choose his mode of entry; but in communicating his observations to others it is of the utmost importance that he should carefully explain the method he has adopted." Mr. Knott's method is usually to write + and − in the sense that $c+2$ means magnitude 10·3 if c be of magnitude 10·1; and in this he is consistent throughout, though he occasionally uses (in the notes) the symbols > and < in a sense which they will not bear numerically. Thus on p. 109, in the note for 1877 February 21, we have the following formulæ as equivalent:—

$$a+2>b=b>\mathrm{U}$$
$$b-(a+2)=\mathrm{U}-b$$

the meaning being that b is as much fainter than a star two-tenths of a magnitude fainter than a as U is fainter than b. See also note on p. 111 to April 27.

Light Curve.—The pamphlet next gives simple directions for plotting the observations on cross-ruled paper, and of Mr. Pogson's expedient for determining the epoch of actual minimum or maximum. "Bisect the straight lines, joining points where the curve in rising and falling passes through *equal magnitudes.*" The point where the (curved) line through these points of bisection, produced if necessary, cuts the light curve indicates the epoch of maximum or minimum.

Mr. Knott had prepared diagrams of his observations of this kind, extending in the case of the well-observed stars to great lengths; but since they add nothing essential to the material printed, it was not considered necessary to reproduce them.

The Ledgers.—In Mr. Knott's pamphlet he recommends the use of a "book specially for variable star observations . . . ruled so as to contain columns for the following particulars, which should form a part of each entry:—The date of observation; the name of the star observed; the size of the telescope with which the observation is made; the magnifying power employed; the light estimates; the resulting magnitudes; and finally a

column for 'Remarks,' which may be of use for the entry of the *colour* of the variable, general estimate of the observations, state of the atmosphere, &c."

No mention is made in the pamphlet of a separate ledger for each star. In a letter to Mrs. Baxendell, dated 1891 March 7, Mr. Knott wrote: "I always feel that I owe him (the late Mr. Joseph Baxendell) a large debt of gratitude for most valuable assistance and advice in regard to variable star work—a branch of science which had a great fascination for both of us. I owe to *him* the idea of a ledger for each star, and have adopted it for such stars as I have had under more or less *regular* observation. There are, however, many casual observations scattered through my observation books which are *un-ledgered* (if I may coin an ugly-looking word)—and every now and then I find I have to spend some time in hunting them up."

These casual observations have not been collected here. The following pages are merely the reproduction of the ledgers, reference being made to the original observation books only when there was something obscure or incorrect in the ledgers. But both sets of books have been presented by Mrs. Knott to the Society and placed in the library, so that they are available for reference. In order that the ledgers should be preserved in the state in which Mr. Knott left them, a MS. copy was made for the printer's use.

Discussion of the Observations.—It would not have been difficult to give a set of elements for each star deduced from these observations, or to compare the observations with elements already published, such as those of Mr. S. C. Chandler's Third Catalogue, which have been printed for each star. But for the complete discussion of the observations they must be associated with others, and to add anything of this kind would alter the character of the present memoir, which as it stands is the simple observation record of thirty years' work by the same observer, working with the same instrument on the same plan. Hence no discussion of the observations has been here undertaken.

At the end of this Introduction will be found a list of the epochs of maxima and minima as determined by Mr. Knott and entered in his ledgers. It appears (in his correspondence with Mr. Baxendell) that he attached some importance to these determinations of epoch by the observer himself; on one occasion he expresses a definite preference for using these determinations rather than rediscussing the observations themselves.

Correction of Proofs, &c.—The proof reading has been done by Mr. Wesley with all care and patience. I have also been through all the figures and remarks independently, though without reference to the MS., except in cases where there seemed to be some mistake. The following corrections to Mr. Knott's MS. have been made :—

A column inserted in his ledgers for the instrument used has been omitted, as he used the same instrument throughout—the 7-inch telescope above mentioned. His symbol for this was (7) ; but as this symbol would not have been intelligible to the casual reader, the word "telescope" has been substituted where necessary.

The column for concluded epoch of maximum or minimum has also been omitted to save space. The dates assigned by Mr. Knott are collected in tabular form at the end of this Introduction.

In the case of *U Cephei* the power used is not mentioned either in the ledgers or the day book. At first the observations were entered on the left-hand page of the day book and thence transferred to the ledger ; but after 1881 November 19 they do not appear in the day books, and seem to have been written straight into the ledger.

In the columns giving the date the time adopted for some years subsequently to 1885 January 1 was the civil time commencing at midnight, as proposed by the Astronomer Royal. But as this practice has not been generally adopted, the times have been expressed in G.M.T. throughout for the sake of uniformity.

There is also in the ledgers a column for "day of century" in addition to the day of month. This column has been omitted because its retention would have inconveniently crowded the page, and its value was (in the opinion of Mr. Chandler) not very great.

In the columns "Deduced Mags." and "Mean Mag." the magnitudes assumed for the comparison stars in the early observations occasionally differ slightly from those ultimately adopted and printed under the chart for each star. In such cases these columns have been corrected, the only exception being the case of *S Aquilæ* mentioned above, where an important change was made in the adopted magnitudes after twenty years. There are in addition to the above systematic discrepancies instances of accidental error, usually one-tenth of a magnitude in amount. These also have been corrected.

In the "Remarks" column there are occasional references to stars denoted x, y, ξ, &c., which there are now no means of identifying. These have usually been cut out, if after carefully seaching the original observation books no small diagram is found for guidance. When such small diagrams were found the stars were added to the chart.

In a few cases of a miscellaneous character where there is some discrepancy the original record has been left as it stands with an explanatory note if possible. It sometimes required considerable trouble to clear up these points, as, for instance, the identification of "Mr. Franks' star" on page 156, note. The most troublesome case, perhaps, was that of the chart for *R* and *S Scorpii*, which was a copy from Chacornac. It was not until after some time that an error of 3′ or 4′ in Chacornac's Chart was suspected; but this error is apparently an unfortunate fact (see pp. 184 and 194).

The diagrams or charts used by Mr. Knott were collected from miscellaneous sources. They have been enlarged or reduced to a uniform scale of three inches to the degree, but are otherwise unaltered. The epoch for each chart has been added, in some cases from a knowledge of the epoch of the chart, which has been obviously copied, in others from computation of the approximate places of the stars. The charts were traced by Mr. Wesley.

It may not be out of place to mention here two cases of curious discrepancy between Mr. Knott's observations and those of other observers which were discussed by him in correspondence with the Baxendells and others without any satisfactory solution being found, so far as I can ascertain.

The first is that of *U Cygni* in 1879. Mr. Knott made the minimum fall on October 8, while Mr. Baxendell, Sen., put it on August 19. Chandler's elements on p. 245 give the minimum at the end of August.

The other case is that of Professor Safarik's observations of *U Geminorum.* Mr. Knott wrote to Mr. Baxendell, Jun., on 1880 March 18 that he had heard that "some of Professor Safarik's results for *U Geminorum* differ materially from ours. . . . The only observations of his I know are in the *Astr. Nachrichten* (2505 and 2688), and I send you with this a copy of them. To any one who knows what observing *U Gem.* is I do not know that there is very much to speak of in the way of difference. I see, however, he has 1884 Jan. 24 U 9·8, while my estimate on that night is 13·3—rather a wide difference —and at the max. of April 1885 his mags. run down sooner than ours."

This "very serious discordance on Jan. 24," as Mr. Knott calls it, in a letter dated 1892 Jan. 13, was not cleared up, although Mr. Knott wrote to Professor Safarik on the subject.

The following brief extracts from letters to the Baxendells have a bearing on the observations :—

"I find a little satisfaction of a certain kind in the little difference between your father's estimates and your own, $0^{M}\cdot 2$, as it confirms a feeling I have experienced that the star (*U Geminorum*) is a *difficult* one to observe, and that differences in estimate which have shown themselves as between your father and myself in regard to this star do not depend solely on differences of atmospheric surroundings and instrument" (Letter of 1885 April 11).

"I am glad to find that we are in fair accord as to the date of max. of *S Cor. Bor.* At the same time it is puzzling to find so fair an agreement in the case of this star—a high coloured one—and so wide a discordance in the case of *U Cygni*" (Letter of 1885 Sept. 2).

"I do not know how it is with you at Birkdale, but *here* we are very apt to have skies so full of moist haze that the field of view is flooded with light, not only when the moon is absent, but even at other times. I have found it of advantage therefore for *faint* stars to use a highish power, 191 or 258, chiefly, I suppose, because it gives a smaller field and a blacker one therefore relatively. At least so it strikes me" (Letter of 1891 Feb. 18).

"As my tendency in regard to red stars is to register them *high* in mag. I think my *U Cygni* obs. are probably not much out" (Letter of 1891 April 23).

Mr. Knott's Determinations of Maxima and Minima.

[The letters in column 5 refer to notes at the end.]

Star's Name.	Place 1900·0. R.A.	Place 1900·0. Dec.	Total Number of Nights of Observation.	Observed Maxima or Minima as determined by Mr. Knott. Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
U Cephei	0 53	+81 20	44	(*a*) ...	...	...	...
U Tauri	4 16	+19 33	101	(*b*) ...	...	...	...
T Tauri	4 16	+19 18	111	(*b*) ...	...	...	...
R Aurigæ	5 9	+53 28	54	(*b*) ...	...	...	...
S Orionis	5 24	− 4 46	199	(*c*) 28518	1878 Jan. 29	Max.	8·9
				31805	1887 Jan. 29	Max.	8·8
R Canis Minoris ...	7 3	+10 11	76	(*b*) ...	...	...	...
V Geminorum ...	7 17	+13 17	174	30371	1883 Feb. 25	Max.	8·65
				(*d*) 31740	1886 Nov. 25	Max.	8·8
				32171	1888 Jan. 30	Min.	14·05
				32572	1889 March 6	Max.	8·6
				33276	1891 Feb. 8	Min.	13·9
				33681	1892 March 19	Max.	9·0
S Canis Minoris ...	7 27	+ 8 32	189	23815	1865 March 15	Max.	7·6
				24145	1866 Feb. 8	Max.	7·4
				24483	1867 Jan. 12	Max.	6·9
				31066	1885 Jan. 20	Max.	7·4
U Canis Minoris ...	7 35	+ 8 37	121	(*e*) 29646	1881 March 2	Min.	9·7
				(*f*) 30712	1884 Feb. 1	Min.	13·2
				31809	1887 Feb. 2	Max.	8·6
				32150	1888 Jan. 9	Max.	9·0
				32535	1889 Jan. 28	Max.	9·1
				(*f*) 33652	1892 Feb. 19	Min.	13·6
				(*f*) 34043	1893 March 16	Min.	13·4
U Geminorum ...	7 49	+22 16	754	24813	1867 Dec. 8	Max.	9·2
				(*g*) 30345	1883 Jan. 30	Max.	9·0
				(*g*) 30706	1884 Jan. 26	Max.	9·6
				(*g*) 30976	1884 Oct. 22	Max.	9·4
				(*g*) 31144	1885 April 8·8	Max.	9·25
				31386 (7)	1885 Dec. 6 or 7	Max.	...
				31746	1886 Dec. 1	Max.	...
				(*h*) 31830	1887 Feb. 23·3	Max.	9·6
				(*g*) (*h*) 32446	1888 Oct. 31	Max.	...
				33372	1891 May 15	Max.	9·5
				(*g*) (*h*) 33542	1891 Nov. 1	Max.	9·5
U Cancri	8 30	+19 14	230	23736	1864 Dec. 26	Max.	8·8

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0. R.A.	Place 1900·0. Dec.	Total Number of Nights of Observation.	Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
U Cancri—(*cont.*) ...	8 30	+19 14	230	25271	1869 Mar. 10	Max.	9·5
				28605	1878 April 26	Max.	9·2
				g) (*h*) 29224	1880 Jan. 5	Max.	8·4
				(*g*) 30748	1884 March 8	Max.	8·5
				(*g*) 31045	1884 Dec. 30	Max.	10 6
				32262	1888 April 30	Max.	8·5
				(*g*) 32560	1889 Feb. 22	Max.	10·9
				(*g*) 34093	1893 May 5 ? ?	Max.	8 9?
R Ursæ Majoris ...	10 37	+69 18	294	23859	1865 April 28	Min.	13·0
				23992	1865 Sept. 8	Max.	6·4
				24183	1866 March 18	Min.	13·0
				24307	1866 July 20	Max.	7 6
				24482	1867 Jan. 11	Min.	13·5
				24598	1867 May 7	Max.	7·3
				24796	1867 Nov. 21	Min.	13·5
				24904	1868 March 8	Max.	7·4
				25097	1868 Sept. 17	Min.	13·6
				25216	1869 Jan. 14	Max.	7·7
				25402	1869 July 19	Min.	13·5
				25507	1869 Nov. 1	Max.	7·1
				26008	1871 March 17	Min.	13·5
				26120	1871 July 7	Max.	7·7
				26426	1872 May 8	Max.	7·7
				28220	1877 April 6	Max.	7·1
				28410	1877 Oct. 13	Min.	13·6
				28516	1878 Jan. 27	Max.	7·0
				28710 ±	1878 Aug. 9 ±	Min.	13·5
				30033	1882 March 24	Max.	7·0
				31115	1885 March 10	Min.	13·2
				31225	1885 June 28	Max.	7·1
				(*g*) 31744	1886 Nov. 29	Min.	13·5
				(*g*) 31828	1887 Feb. 21	Max.	8·05
				(*g*) 32032	1887 Sept. 13	Min.	13·35
				(*g*) 32140	1887 Dec. 30	Max.	7·85
S Ursæ Majoris ...	12 39	+61 38	294	23990	1865 Sept. 6	Min.	11·8
				24104	1865 Dec. 29	Max.	7·9
				24203	1866 April 7	Min.	12·0
				24333	1866 Aug. 15	Max.	7·3
				24436	1866 Nov. 26	Min.	12·0

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0. R.A.	Place 1900·0. Dec.	Total Number of Nights of Observation.	Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
S Ursæ Majoris—(*cont.*)	12 39	+61 38	294	24532	1867 March 2	Max.	7·9
				24664	1867 July 12	Min.	11·8
				24763 ±	1867 Oct. 19 ±	Max.	8·3
				24879	1868 Feb. 12	Min.	12·3
				24993	1868 June 5	Max.	7·7
				25113	1868 Oct. 3	Min.	12·5
				25214	1869 Jan. 12	Max.	7·8
				25396	1869 July 13	Max.	7·6
				(*g*) 25566 ±	1869 Dec. 30 ±	Min.	12·0
				(*g*) 26011 ±	1871 March 20 ±	Min.	13·0
				26113	1871 June 30	Max.	7·8
				28188	1877 March 5	Max.	8·0
				28297	1877 June 22	Min.	12·1
				28393	1877 Sept. 26	Max.	7·4
				28616	1878 May 7	Max.	7·6
				30010	1882 March 1	Max.	7·5
				(*i*) 31073	1885 Jan. 27	Min.	11·8
				31171	1885 May 5	Max.	7·25
				(*g*) 31288	1885 Aug. 30	Min.	12·5
				(*g*) 31633	1886 Aug. 10	Max.	7·7
				(*g*) 31747	1886 Dec. 2	Min.	13·05
				(*s*) 31848	1887 March 13	Max.	7·9
				31968	1887 July 11	Min.	11·5
				32081 ±	1887 Nov. 1 ±	Max.	7·8
				(*g*) 32202	1888 March 1	Min.	13·0
S Coronæ Borealis ...	15 17	+31 44	200	(*g*) 24313	1866 July 26	Max.	7·8
				(*g*) 24696	1867 Aug. 13	Max.	6·55
				(*g*) 24929	1868 April 2	Min.	11·8
				(*g*) 25038	1868 July 20	Max.	6·9
				(*g*) 25399	1869 July 16	Max.	7·25
				(*g*) 25756 ±	1870 July 8 ±	Max.	6·5
				(*g*) 26117	1871 July 4	Max.	6·8
				(*g*) 26500	1872 July 21	Max.	7·4
				(*g*) 28278	1877 June 3	Max.	7·0
				(*g*) 28641 − 3	1878 June 1 − 3	Max.	6·8
				(*g*) 31171 ±	1885 May 5 ±	Max.	7·6
R Scorpii	16 11	−22 42	184	29382	1880 June 11	Max.	9·9
				30505	1883 July 9	Max.	10·0
				(*g*) 31620	1886 July 28	Max.	9·8

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0.		Total Number of Nights of Observation.	Observed Maxima or Minima as determined by Mr. Knott.			
	R.A.	Dec.		Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
S Scorpii	16 11	−22 39	194	24622	1867 May 31	Max	9·5
				24978	1868 May 21	Max.	9·6
				28334	1877 July 29 ±	Max.	9·7
				28683	1878 July 13	Max.	9·7
				29394	1880 June 23 ±	Max.	11·0
				30104	1882 June 3	Max.	9·5
R Cygni	19 34	+49 59	114	(*b*) ...	...	...	...
S Cygni	20 3	+57 42	380	23281	1863 Sept. 28	Max.	9·4
				23608	1864 Aug. 20	Max.	9·6
				23938	1865 July 16	Max.	9·6
				24257	1866 May 31	Max.	9·3
				(*d*) 24582	1867 April 21	Max.	9·2
				(*k*) 24897	1868 March 1	Max.	9·2??
				(*l*) 25222	1869 Jan. 20	Max.	9·3
				25545	1869 Dec. 9	Max.	9·6
				(*m*) ?	1870 Oct. ?	Max.	9·0
				26193	1871 Sept. 18	Max.	10·0
				26510	1872 July 31	Max.	9·0
				28129	1877 Jan. 5	Max.	9·8
				28433	1877 Nov. 5	Max.	9·0
				(*n*) 28772	1878 Oct. 10 ±	Max.	?
				29085	1879 Aug. 19	Max.	9·2
				29396?	1880 June 25?	Max.	10·4
				29711	1881 May 6	Max.	9·3
				30364	1883 Feb. 18	Max.	9·2
				31016	1884 Dec. 1	Max.	10·1
				31673 ±	1886 Sept. 19 ±	Max.	9·7
				31999 ±	1887 Aug. 11 ±	Max.	10·4??
				33303	1891 March 7	Max.	9·7
				33631	1892 Jan. 29	Max.	9·8
				33944	1892 Dec. 7	Max.	9·0
				34275	1893 Nov. 3	Max.	9·7
S Aquilæ	20 7	+15 19	447	(*g*) 25003	1868 June 15	Min.	10·7
				(*g*) 25069	1868 Aug. 20	Max.	9·0
				(*o*) ...	1868 Nov. ?	Max.	?
				(*p*) ...	1868 Dec. ?	Min.	?
				(*g*) 29923	1881 Dec. 4	Max.	9·1
				(*g*) 31213	1885 June 16	Min.	11·0
				(*g*) 31599?	1886 July 7?	Min.	11·0

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0. R.A.	Place 1900·0. Dec.	Total Number of Nights of Observation.	Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
S Aquilæ—(*cont.*) ...	20 7	+15 19	447	31688	1886 Oct. 4	Max.	9·2
				31747	1886 Dec. 2	Min.	10·75
				31967	1887 July 10	Max.	9·2
				32103	1887 Nov. 23	Max.	9·2
				32824	1889 Nov. 13	Max.	9·2
				33123	1890 Sept. 8	Min.	10·75
				(*g*) 33804	1892 July 20	Min.	10·8
				(*g*) 33854	1892 Sept. 8	Max.	8·9
				(*g*) 33926	1892 Nov. 19	Min.	10·8
U Cygni	20 16	+47 35	321	25860	1870 Oct. 20	Min.	9·4
				26099	1871 June 16	Max.	8·0
				26326	1872 Jan. 29	Min.	9·9
				26557	1872 Sept. 16	Max.	7·8
				28198	1877 March 15	Min.	10·6
				28418	1877 Oct. 21	Max.	7·8
				28656	1878 June 16	Min.	10·7
				28842	1878 Dec. 19	Max.	7·9
				(*g*) 29135	1879 Oct. 8	Min.	11·0
				29324	1880 April 14	Max.	7·8
				29560	1880 Dec. 6	Min.	11·5
				29800	1881 Aug. 3	Max.	8·1
				30012	1882 March 3	Min.	11·6
				30252	1882 Oct. 29	Max.	8·0
				30480	1883 June 14	Min.	11·5
				30712	1884 Feb. 1	Max.	7·8
				30977	1884 Oct. 23	Min.	11·2
				31182	1885 May 16	Max.	7·7
				31640 ±	1886 Aug. 17 ±	Max.	7·9
				31927	1887 May 31	Min.	10·6
				32112	1887 Dec. 2	Max.	7·8
				32368	1888 Aug. 14	Min.	10·3
				32570	1889 March 4	Max.	8·0
				32826	1889 Nov. 15	Min.	10·3
				33020	1890 May 28	Max.	7·8
				33746	1892 May 23	Min.	11·05
				33964	1892 Dec. 27	Max.	8·0
T Delphini	20 41	+16 2	421	23962	1865 Aug. 9	Max.	8·8
				24303	1866 July 16	Max.	9·2
				24656	1867 July 4	Max.	9·2

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0. R.A.	Place 1900·0. Dec.	Total Number of Nights of Observation.	Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
T Delphini—(*cont.*)	20 41	+16 2	421	24971	1868 May 14??	Min.	??
				26614	1872 Nov. 12	Max.	9·7
				28283	1877 June 8	Max.	9·7
				29926	1881 Dec. 7	Max.	8·7
				30252	1882 Oct. 29	Max.	9·6
				30594	1883 Oct. 6	Max.	9·6
				30939	1884 Sept. 15	Max.	9·0
				31275	1885 Aug. 17	Max.	10·3
				33245	1891 Jan. 8	Max.	9·6
				33570 ±	1891 Nov. 29 ±	Max.	10·1
				33904	1892 Oct. 28	Max.	8·7
				34241	1893 Sept. 30	Max.	9·5
R Vulpeculæ ...	21 0	+23 26	631	22579	1861 Oct. 26·3	Min.	13·6
				22644	1861 Dec. 30	Max.	8·4
				22923	1862 Oct. 5·0	Max.	7·8
				23271	1863 Sept. 18·0	Min.	13·2
				23333	1863 Nov. 19·4	Max.	7·6
				23546	1864 June 19·5	Min.	13·2
				23604	1864 Aug. 16·3	Max.	7·5
				23684	1864 Nov. 4·0	Min.	13·1
				23748	1865 Jan. 7·3	Max.	7·7
				23886	1865 May 25·5	Max.	7·8
				23959	1865 Aug. 6·3	Min.	12·8
				24019	1865 Oct. 5·5	Max.	7·5
				24089	1865 Dec. 14·3	Min.	13·7
				24228	1866 May 2·5	Min.	13·2
				24294	1866 July 7·0	Max.	7·6
				24362	1866 Sept. 13·5	Min.	12·3
				24425	1866 Nov. 15·5	Max.	7·1
				24632	1867 June 10·5	Min.	13·4
				24704	1867 Aug. 21·0	Max.	7·8
				24775	1867 Oct. 31·0	Min.	13·5
				24834	1867 Dec. 29·0	Max.	7 9
				25032	1868 July 14·0	Min.	13·0
				25105	1868 Sept. 25·5	Max.	7·9
				25176	1868 Dec. 5·0 ±	Min.	13·6
				25444	1869 Aug. 30·5	Min.	12·3
				25512	1869 Nov. 6·0	Max.	7·6
				25719	1870 June 1·0	Min.	13·2

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0.		Total Number of Nights of Observation.	Observed Maxima or Minima as determined by Mr. Knott.			
	R.A.	Dec.		Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
R Vulpeculæ—(*cont.*)	21 0	+23 26	631	26130	1871 July 17	Min.	13·8
				26196	1871 Sept. 21	Max.	8·4
				26263	1871 Nov. 27	Min.	13·5
				26478	1872 June 29	Max.	8·2
				26541	1872 Aug. 31	Min.	13·2
				26596	1872 Oct. 25	Max.	7·9
				26674	1873 Jan. 11	Min.	12·9
				28112	1876 Dec. 19 ±	Max.	8·0
				28315	1877 July 10	Min.	12·7
				28378	1877 Sept. 11 ±	Max.	8·2
				28455	1877 Nov. 27	Min.	13·2
				28511	1878 Jan. 22	Max.	7·6
				28650	1878 June 10	Max.	8·0
				28784	1878 Oct. 22	Max.	7·3
				29069	1879 Aug. 3	Max.	8·1
				29130	1879 Oct. 3 ±	Min.	12·3
				29194	1879 Dec. 6	Max.	7·8
				29396	1880 June 25	Min.	13·4
				29485	1880 Sept. 22	Max.	8·7
				(*r*) 29540	1880 Nov. 16	Min.	13·1
				29741	1881 June 5 ±	Max.	8·3
				29816	1881 Aug. 19 ±	Min.	12·8
				29876	1881 Oct. 18	Max.	7·6
				30223	1882 Sept. 30	Min.	13·0
				30629	1883 Nov. 10	Min.	12·9
				30905	1884 Aug. 12	Min.	12·7 ±
				30970	1884 Oct. 16	Max.	7·6
				31247	1885 July 20	Max.	8·2
				31597	1886 July 5	Min.	13·6
				32009	1887 Aug. 21 ±	Min.	12·8
				32069	1887 Oct. 20 ±	Max.	7·8
				32423 ?	1888 Oct. 8 ?	Min.	12·6
				32477	1888 Dec. 1	Max.	7·8
				32828	1889 Nov. 17	Min.	13·6
				33102	1890 Aug. 18	Min.	12·0
				33163	1890 Oct. 18	Max.	7·8
				33238	1891 Jan. 1	Min.	12·8
				33575	1891 Dec. 4	Max.	7·6
				33856	1892 Sept. 10 ±	Max.	8·0

Mr. Knott's Determinations of Maxima and Minima—continued.

Star's Name.	Place 1900·0.		Total Number of Nights of Observation.	Observed Maxima or Minima as determined by Mr. Knott.			
	R.A.	Dec.		Day of Century.	Day of Year.	Max. or Min.	Mag.
	h m	° ′					
R Vulpeculæ—(*cont.*)	21 0	+23 26	631	33928	1892 Nov. 21	Min.	13·4
T Cephei	21 8	+68 5	316	29754	1881 June 18	Min.	9·5
				29963	1882 Jan. 13	Max.	6·4
				30154	1882 July 23	Min.	9·8
				30352	1883 Feb. 6	Max.	6·3
				30550	1883 Aug. 23	Min.	9 9
				30747	1884 March 7	Max.	6·75
				30908	1884 Aug. 15	Min.	9·7
				31138	1885 April 2	Max.	6·3
				31304	1885 Sept. 15	Min.	9·6
				31496	1886 March 26	Max.	6·3
				31700	1886 Oct. 16	Min.	9·6
				31861	1887 March 26	Max.	6·3
				32094	1887 Nov. 14	Min.	9·2

Notes.

(*a*) [The epochs determined for this short period variable are given at the head of each night's observation.—Ed.]

(*b*) [No entries of epoch have been made by Mr. Knott for these five stars, U Tauri, T Tauri, R Aurigæ and R Canis Minoris, R Cygni.—Ed.]

(*c*) From observation by Mr. Baxendell between my January 30 and February 14 observations, the max. appears to have fallen *later*, on February 3 or February 5.

(*d*) This record is in pencil only and marked ? ?

(*e*) Secondary minimum.

(*f*) Principal minimum.

(*g*) In pencil.

(*h*) Probable max. ?

(*i*) From observations by Mr. J. Baxendell, jun., it appears that my estimates of December 15 and January 7 are considerably too high, and that the minimum fell on January 18.

(*k*) Light curve very imperfect.

(*l*) Observation rather doubtful.

(*m*) Date entered " 1870 end of October."

(*n*) " Very doubtful." No magnitude entered.

(*o*) Early in November. Secondary maximum. No magnitude given.

(*p*) Early in December. Secondary minimum. No magnitude given.

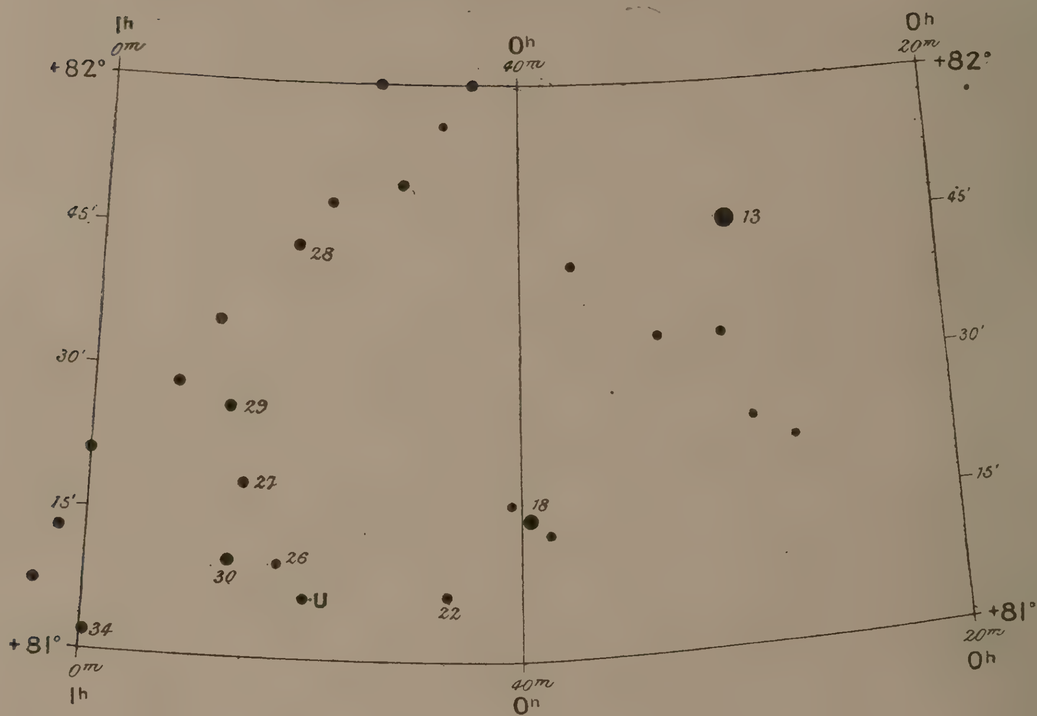
(*q*) N.B.—Min. according to Baxendell August 19; mag. 11·4.

(*r*) " Well observed."

(*s*) Subsidiary max, on rising curve February 6; mag. 8·8.

Mr. Knott's *diagram, epoch* 1855.

U Cephei.



BD+81° No. 13 = 6·5 mag.

18 = 7·6, 7·8, 8·2	29 = 8·3 mag.
22 = 9·4	30 = 8·1
26 = 10·7	34 = 8·6
27 = 8·4	

Mags. Baxendell.

18 = 7·4 mag. (var.)	26 = 10·8 mag.
22 = 9·4	30 = 8·1
27 = 8·7	34 = 8·5

U Cephei.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astr. Journal*, No. 379).

No. 320, U Cephei, R.A. for $1900{\cdot}0 = 0^h\ 53^m\ 23^s$, Decl. $+81°\ 20'{\cdot}2$.
Annual variations $+5^s{\cdot}09$ and $+0'{\cdot}33$.
R.A. for $1855{\cdot}0 = 0^h\ 49^m\ 38^s$, Decl. $+81°\ 5'{\cdot}5$.
Redness 0. Max. mag. $= 7{\cdot}1$. Min. $= 9{\cdot}2$.
Minimum, 1880 June $23^d\ 9^h\ 28^m{\cdot}0 + 2^d\ 11^h\ 49^m\ 38^s{\cdot}25\ E + 95^m \sin(0°{\cdot}08\ E + 283°)$
(from 50 observations of minima, including observations in 1828, and in 1880–1893)
E being the number of periods elapsed since the principal epoch.

Discovered by CERASKI, 1880. Algol-type. Light curve, unusually flat at minimum and unsymmetric; decrease more rapid than increase. Oscillations occupy one-sixth of period, or 10 hours. Nearly stationary for 2 hours at minimum. See investigations, *A.J.*, ix. 49, and xiii. 45.

Note by the Editor.—This is the only variable of short period in the series observed by Mr. KNOTT. The arrangement here adopted is copied exactly from the written ledger kept by Mr. KNOTT, excepting that the gaugings of the comparison stars have, for convenience of printing, been taken out of the "Remarks" column, and are here collected, as also one or two special notes. The observations marked *f* were made with the finder. The symbol (7) used in the MS. for the 7-inch telescope has been replaced by telescope or tel. simply.

U Cephei.

Date.	Mag.	Date.	Mag.	Date.	Mag.
Star B.D. + 81°, No. 13 (Mean of all 6·60).					
1880 Oct. 29	6·7	1880 Dec. 9	6·5	1881 Mar. 29	6·7
Nov. 2	6·5	1881 Jan. 7	6·5	Oct. 5	6·7
,, 3	6·5	,, 7	6·7		
Dec. 2	6·5	Feb. 10	6·7		
Star B.D. + 81°, No. 18 (Mean of all 7·70).					
1880 Nov. 8	8·3 *f*	1881 Apr. 26	7·5	1882 Apr. 27	7·5
Dec. 2	7·8 ?	May 3	7·5	1883 Mar. 2	7·4
,, 9	8·1	,, 8	7·6	,, 12	7·4
1881 Jan. 6	7·8	Aug. 6	8·1	Apr. 1	7·5
,, 7	8·0	Sept. 27	7·9	Oct. 20	8·0
Mar. 14	7·6	Oct. 5	7·9	1884 Feb. 29	7·6
,, 29	7·6	Dec. 21	8·1	1885 Mar. 14	7·3
Apr. 3	7·6 *f*	1882 Mar. 18	7·5	1887 Jan. 26	7·7
,, 13	7·5	Apr. 7	7·5		
Star B.D. + 81°, No. 22 (Mean of all 9·39).					
1880 Oct. 23	9·4 *f*	1880 Nov. 8	9·3 *f*	1882 Nov. 30	9·4
,, 23	9·3 *f*	Dec. 2	9·4	1883 Mar. 2	9·4
,, 29	9·4	,, 9	9·4	,, 12	9·4
Nov. 2	9·4	1881 Jan. 6	9·4	Apr. 1	9·4
,, 2	9·3	,, 6	9·5	Oct. 20	9·4
,, 3	9·4	,, 7	9·4	,, 20	9·5
,, 3	9·3	Mar. 29	9·4	1885 Mar. 14	9·4
,, 3	9·3	Apr. 13	9·4		
Star B.D. + 81°, No. 25 (Mean of all 7·25).					
1880 Nov. 3	7·2	1881 Jan. 7	7·4	1881 Mar. 26	7·4
,, 8	7·3 *f*	Feb. 10	7·1	Apr. 26	7·1
Dec. 9	7·2	,, 15	7·3	,, 26	7·2
1881 Jan. 7	7·3	Mar. 14	7·3	Oct. 5	7·2

U Cephei—continued.

Date.	Mag.	Date.	Mag.	Date.	Mag.
Star B.D. +81°, No. 26 (Mean of all 10·63).					
1880 Oct. 23	10·3 *f*	1881 Jan. 6	10·7	1881 Apr. 3	10·6 *f*
„ 23	10·5 *f*	„ 7	10·8	„ 26	10·6
„ 29	10·4	„ 7	10·9	„ 26	10·7
Nov. 2	10·5	Feb. 10	10·8	May 3	10·7 ? *f*
„ 2	10·3	„ 10	10·9	„ 8	10·7 *f*
„ 3	10·3	„ 15	10·7 *f*	Aug. 6	10·9
„ 3	10·5	Mar. 26	10·7	Sept. 27	10·7
„ 8	10·4 *f*	„ 29	10·7 *f*	1882 Nov. 30	10·7
„ 8	10·5 *f*	Apr. 3	10·7 *f*	1883 Mar. 2	10·7
Star B.D. +81°, No. 27 (Mean of all 8·43).					
1880 Oct. 23	8·4 *f*	1880 Dec. 2	8·4	1881 Oct. 5	8·6 ? ?
„ 23	8·5 *f*	„ 9	8·4	1882 Apr. 27	8·4
„ 23	8·5 *f*	1881 Jan. 6	8·4	Nov. 30	8·4
„ 29	8·4	„ 7	8·4	1883 Mar. 12	8·4
„ 29	8·5	Mar. 26	8·4	Apr. 1	8·4
Nov. 2	8·4	Apr. 13	8·4	Oct. 20	8·5
„ 3	8·4	May 8	8·4	„ 20	8·4
„ 8	8·4 *f*	Oct. 5	8·5	1885 Mar. 14	8·4
Star B.D. +81°, No. 28 (Mean of all 9·11).					
1881 Jan. 7	9·0	1881 Mar. 29	9·3	1882 Nov. 30	9·0
„ 7	9·1	Oct. 2	9·2	1883 Mar. 2	9·0
Mar. 29	9·3	Dec. 21	9·05	Oct. 20	9·0
Star B.D. +81°, No. 29 (Mean of all 8·34).					
1880 Oct. 29	8·3	1881 Jan. 6	8·3	1882 Nov. 30	8·3
Nov. 2	8·3	„ 7	8·3	1883 Mar. 12	8·3
„ 3	8·4	May 8	8·3	Apr. 1	8·3
„ 8	8·4 *f*	1882 Apr. 27	8·5 ?	Oct. 20	8·4
Dec. 9	8·3 ?	„ 27	8·4 ?		

U Cephei—continued.

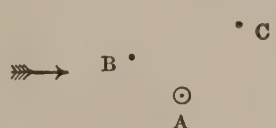
Date.	Mag.	Date.	Mag.	Date.	Mag.
Star B.D. +81°, No. 30 (Mean of all 8·10).					
1880 Oct. 23	8·1 *f*	1881 Jan. 6	8·1	1881 Apr. 26	8·1
„ 23	8·1 *f*	„ 7	8·1	May 8	8·1
„ 23	8·1 *f*	„ 7	8·0	Oct. 5	8·1
„ 29	8·1	Feb. 10	8·1	1882 Apr. 27	8·1
„ 29	8·1	„ 15	8·1	1883 Mar. 2	8·1
Nov. 3	8·0	Mar. 14	8·1	„ 12	8·1
„ 3	8·1	„ 26	8·1	Apr. 1	8·1
„ 8	8·1 *f*	„ 26	8·2	Oct. 20	8·1
Dec. 2	8·1	„ 29	8·1	1885 Mar. 14	8·1
„ 9	8·1	Apr. 3	8·1 *f*		
„ 9	8·0	„ 13	8·1		
Star B.D. +81°, No. 34 (Mean of all 8·60).					
1880 Oct. 23	8·8 *f*	1881 Jan. 6	8·5	1881 Oct. 5	8·5 ?
„ 23	8·6 *f*	„ 6	8·6	1882 Apr. 27	8·6
„ 23	8·6 *f*	„ 7	8·6	1883 Mar. 2	8·6
„ 29	8·6	Mar. 29	8·6	„ 12	8·6
„ 29	8·7	„ 29	8·7	Apr. 1	8·6
Nov. 2	8·6	Apr. 3	8·6 *f*	Oct. 20	8·6
„ 3	8·6	„ 13	8·6	1885 Mar. 14	8·6
Dec. 2	8·6	May 8	8·6		

Collecting these mean results they are compared in the following table with the working magnitudes adopted by Mr. Knott, given by him on the first page of his MS. ledger; and with Mr. Baxendell's magnitudes, also given :—

U Cephei—continued.

Star.	Above Mean.	Mr. Knott's Adopted.	Remarks.	Mr. Baxendell.
B.D. + 81°, No. 13	6·60	6·5	...	...
„ 18	7·70	7·6 7·8 8·2	Entered in pencil 7·6 7·5 7·4 *used* in the ledger.	7·4 (var.)
„ 22	9·39	9·4	...	9·4
„ 25	7·25	...	...	...
„ 26	10·63	10·7	In pencil also 10·4 10·9 10·7.	10·8
„ 27	8·43	8·4	...	8·7
„ 28	9·11	...	...	...
„ 29	8·34	8·3	...	...
„ 30	8·10	8·1	...	8·1
„ 34	8·60	8·6	...	8·5

On several occasions Mr. Knott remarks on two comites of *U Cephei*, shown in the subjoined figure (erect image) :—



On 1880 October 23 he notes : “ Small comes (B) *n.f.* ; distance 10″?. Position-angle 70° ± ?, 60°?, 60? ; mag. 11 or 11½. A second minute speck suspected at C?? and ∠CAB = 90° ±.”

On 1880 October 29 he notes B as bluish and 11½ or 12th mag., and C was suspected “ rather further off than B.”

On 1880 November 2. B bluish decidedly, 11½ mag. est. Well seen. P = 60°, D = 10″ or 12″ ±. C fainter, mag. 13, and rather further off. ∠CAB = 80°, hardly = 90°. At $10^h 45^m$ B was visible with 3·7-inch, and thus not *less* than 12th mag. C visible with 6-inch, therefore 13th mag.

On 1881 May 8. The two comites well seen with power 191.

On 1885 March 14. Two comites well seen.

Finally, there is the following note on the page of the ledger usually left blank, and opposite the observations of 1884 March 20.

U Cephei—continued.

Elements of *U Cephei* from 20 minima of following dates :—

	h m		h m		h m
1880 Oct. 23	11 27	1881 Oct. 2	11 47	1883 Mar. 12	11 49
Nov. 2	11 0	„ 17	10 44	„ 22	11 10
Dec. 2	9 0	1882 Mar. 18	12 21	Apr. 1	10 29
1881 Apr. 3	12 24	Apr. 7	11 5	Oct. 20	8 34
„ 13	11 44	„ 27	9 45	1884 Feb. 29	11 36
May 3	10 23	Oct. 31	8 40	Mar. 20	10 13
„ 8	10 1	1883 Mar. 2	12 36		

$P = 2^{\mathrm{d}}\cdot4928722$. Epoch $30059^{\mathrm{D.C.}}\cdot9264142 = 1882$ Apr. $19\cdot9264142$

Mr. Baxendell's Elements from same 20 minima are (sent to *Astr. Nach.*, 1884 May 17, printed in No. 2596, p. 109) :—

$P = 2^{\mathrm{d}}\cdot4928744$ Epoch $30059^{\mathrm{D.C.}}\cdot9264143 = 1882$ Apr. $19\cdot9264143$

These elements are subsequently compared by Mr. Knott with his observations on three occasions, viz.—

Date.	Observed Min.	Predicted.
	h m	h m
1885 Mar. 14	9 32	9 32
„ 19	9 12	9 11
1887 Jan. 26	10 45	10 19

H. H. T., *Editor.*

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
1880 October 23 (Saturday). Minimum ($9^m \cdot 1$) at $11^h\ 27^m$ G.M.T. = $11^h\ 36^m \cdot 3$ Paris M.T.					
h m					
9 5	= 30	8·1	...	8·1	Clouds coming over.
10 25	Much less than 30, between 34 and 22	9·0	...	9·0	Slightly ruddy.
10 47	... ...	...	9·0 9·1	9.05	
11 7	... ...	...	9·1	9·1	
11 39	... ...	...	9·0	9·0	
12 30	... ...	...	8·9 9·0	8·95	
12 44	... ...	...	8·8	8·8	
13 7	... ...	...	8·6	8·6	
13 16	= 27	8·4	8·5	8·45	
13 50	= 30	8·1	8·1	8·1	White, as 30. Not ruddy now.
13 55	Certainly = 30 at least, perhaps brighter	8·1 – ?	...	8·1 –	
14 0	30–1	8·0	8·0	8·0	Barely so blue a white as 30?
Magnifying power 191.					
1880 October 29 (Friday).					
8 35	... ...	...	7·4	...	White. A bluish comes; and another suspected; see note at commencement.
9 14	... ...	...	7·4	...	
10 47	... ...	...	7·4 7·3	...	
11 20	... ...	...	7·4 7·3	...	
1880 November 2 (Tuesday). Minimum ($9^m \cdot 1$) at $11^h\ 0^m$ G.M.T. = $11^h\ 9^m \cdot 3$ Paris M.T.					
					A clear night. N.E. wind. Definition poor but clear. No interruptions by cloud.
6 19	... ...	...	7·3	...	Var. bluish white.
6 55	... ...	...	7·3 barely 7·2	...	
7 10	... ...	...	7·3	...	
7 43	... ...	...	7·6 ? ?	...	
7 52	... ...	...	7·4	...	
8 0	... ...	...	7·4	...	
8 18	Var. = 30 (So E.K.) ...	8·1	...	...	
8 43	Var. = 27 orange tint ...	8·4	8·4	...	
9 35	Var. = $\frac{1}{2}(27 + 22)$ decidedly ruddy	8·9	...	...	
9 45	Var. gauged, 9·0 ...	...	9·0	...	

U Cephei.—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
1880 NOVEMBER 2 (Tuesday)—*continued.*					
h m 10 30	Var. gauged, 9·1, ruddy orange, 30 = 8·1, 22 9·4, 27 rather > 29 now I think	...	9·1	...	
11 0	34 + 4 ; 22 − 4	9·0	9·0 9·1	...	
11 40	... ...	...	9·1	...	Orange tint or ruddy orange. Light a little unsteady?
12 10	... ...	...	9·1 9·0	...	
12 20	... ...	...	8·8	...	Var. beginning to brighten up?
12 30	Var = 34 8·6 mag. ...	...	8·6	...	Colour yellow now?
12 47	= 27	8·4	8·4	...	
13 0	Var = 30 (So E.K.) ...	8·1	...	...	
13 10	30 − 1	8·1	8·1	...	White.
13 55	... ...	...	7·4	...	
14 5	... ...	...	7·3	...	Var. bluish white.
1880 NOVEMBER 3 (Wednesday). Wind N.E. Clear. Variable white or bluish white. Very similar in tone to 30. Comparison stars gauged; see note at commencement.					
1880 NOVEMBER 8 (Monday). 8^h 15^m—8^h 45^m magnitudes of comparison stars gauged; see note at commencement.					
				7·3	Magnitude of variable (at 8^h 15^m?).
1880 NOVEMBER 22 (Monday). Minimum at 9^h 30^m G.M.T. = 9^h $39^m{\cdot}3$ Paris M.T.					
6 10	30 − 6 − 7	7·4 7·5	...	7·45	Clouds troublesome.
6 40	30 − 3	7·8	...	7·8	Observation difficult. Cloud and haze.
7 0	= 30	...	...	8·1	Both in finder and large telescope, slight orange tint? or full yellow. 115.
7 17	= 27	...	...	8·4	
7 35	= 27 + 2	...	...	8·6	= 34. But qu. 34 rather brighter than 8·6? Decidedly ruddy tint.
8 1	27 + 5 ; 34 + 3 ; 22 − 4 ...	8·9 8·9 8·9	...	8·9	Decidedly ruddy. Clouds troublesome.
8 33	27 + 6 ; 22 − 3	9·0 9·0	...	9·0	About 9th magnitude est. Ruddy and indistinct, but qu. is this owing to cloud and haze which is troublesome? Observation of ascending curve impossible. Persistent cloud over sky from 9^h 30^m to 12^h.

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
1880 December 2 (Thursday). Minimum ($9^m{\cdot}2$) at $9^h\ 0^m$ G.M.T. $= 9^h\ 9^m{\cdot}3$ Paris M.T.					
h m					
5 36	30−2	7·9	...	7·9	Light orange tint? Rather hazy.
6 1	=30	8·1	...	8·1	Powers 70 and 89; also finder. A slight orange tint as compared with 30.
6 13	=30	8·1	...	8·1	
6 49	27+1?	8·5	...	8·5	Ruddy orange.
6 55	=34	8·6	...	8·6	Decided orange tint.
7 5	30+7; 22−6; 27+4; 34+2	8·8 8·8 8·8 8·8	...	8·8	Orange tint.
7 50	30+9; 27+6; 22−4 ...	9·0 9·0 9·0	...	9·0	
8 24	30+10; 29−3	9·1 9·1	...	9·1	Decidedly ruddy. With power 191 the two small comites seen.
8 55	30+10+11; 22−2−1...	9·1 9·2 9·2 9·3	...	9·2	Decidedly orange ruddy.
8 59	22−1	9·3	...	9·3	
9 1	22−2	9·2	...	9·2	
9 58	30+10; 22−3	9·1 9·1	...	9·1	Brighter than it was?
10 25	34+1; 27+3; 22−7 ...	8·7 8·7 8·7	...	8·7	
10 32	=27	8·4	...	8·4	Full yellow. Not so ruddy as it was.
10 50	30+2; 27−1	8·3 8·3	...	8·3	
11 1	=30	8·1	...	8·1	White, hardly so blue or white as 30.
11 20	30−0−1...	8·1 8·0	...	8·05	
11 22	30−1	8·0	...	8·0	White.
11 30	30−1	8·0	...	8·0	
11 40	30−3	7·8	7·8	7·8	
11 45	As much > 30 as 30 > 27...	7·8	...	7·8	
11 47	7·7 7·8 gauged	...	7·75	7·75	
First part of evening sky rather hazy. Clear at latter part. Still. Good definition.					
1881 January 6. Minimum ($9^m{\cdot}1$) at $6^h\ 36^m$ ± G.M.T. $= 6^h\ 45^m{\cdot}3$ Paris M.T.					
5 50	27+6; 22−4	9·0 9·0	9·0	9·0	With full aperture and power 70. Orange tint decidedly.
6 9	22−2	9·2	9·2	9·2	Seems to fluctuate to the extent of a tenth or two.
6 30	30+10; 22−3	9·1 9·1	...	9·1	
6 33	... ...	...	9·2	9·2	
6 41	... ...	...	9·0	9·0	
6 45	22−3	9·1	...	9·1	
7 0	22−3; 28(9·0)+1 ...	9·1 9·1	...	9·1	
7 25	28+1; 22−3	9·1 9·1	9·1 9·2	9·1	
7 37	=28; 22−4	9·0 9·0	...	9·0	Brightening up?

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
	1881 January 6—*continued.*				
h m					
7 45	28−1 ; 22−5	8·9 8·9	8·9	8·9	Light unsteady. Clear orange tint. 115.
7 53	27+2 ; 28−4	8·6 8·6	8·6	8·6	8·6 gauged at 7·55.
7 58	=27 ; 29+1	8·4 8·4	...	8·4	
8 5	Certainly as bright as 27	...	...	...	
8 10	=29	8·3	...	8·3	Full yellow with orange tinge.
8 15	Certainly=29	8·3 8·3−?	...	8·3−?	
8 30	30+1 ; 29−1	8·2 8·2	...	8·2	
8 45	=30	8·1	...	8·1	Slightly yellow as compared with 30.
8 48	... ...	...	8·0	8·0	
8 54	... ...	7·8	7·8	7·8	Bluish white.
9 0	... ...	...	7·7 7·6	7·65	
	1881 March 29. Minimum ($9^m·4$) at 12^h 45^m G.M.T. = 12^h $54^m·3$ Paris M.T.				
	28 assumed 9·0	...	...	...	A persistently cloudy sky prevented any observation earlier in the evening.
11 35	28+2 ; 22−2	9·2 9·2	...	9·2	Ruddy orange tint decided.
11 45	=22	9·4	9·4	9·4	
12 0	... ...	...	9·4	9·4	
12 25	22+0+1...	9·4 9·5	9·4	9·4	
12 35	=22	9·4	9·4	9·4	
12 50	=22	9·4	...	9·4	
13 16	=22	9·4	...	9·4	
13 20	=22	9·4	9·4	9·4	
13 30	=22	9·4	...	9·4	
13 35	=22	9·4	...	9·4	Light a little unsteady? Fine orange tint.
13 45	=22	9·4	...	9·4	Possibly a shade of a doubt whether U may not be slightly the brighter.
13 55	22−1	9·3	...	9·3	Certainly slightly brighter than 22, both in tel. and the finder.
14 0	22−2	9·2	9·2	9·2	
14 5	... ...	...	9·0	9·0	
14 15	=34	8·6	...	8·6	
14 20	=29	8·3	8·3 8·4	8·3	Slight yellow tinge.
14 30	... ...	...	8·2 8·3	8·25	
14 37	30+1	8·2	8·2	8·2	
14 45	=30	8·1	...	8·1	Equal in finder and in tel.
14 50	30−	8·1	...	8·1	Certainly slightly brighter than 30.

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags	Mag. Gauged.	Mean Mag.	Remarks.
1881 April 3 (Sunday). Minimum ($9^{m}\cdot4$) at 12^{h} 24^{m} G.M.T. $=12^{h}$ $33^{m}\cdot3$ Paris M.T.					
h m 8 0	... ...	...	...	7·2	Bluish white.
8 45	=18	7·6	7·6	7·6	
8 55	18+1	7·7	...	7·7	
9 5	18+2; 30−3	7·8 7·8	7·8	7·8	White bluish. A cold E.N.E. wind with strong gusts or squalls at times.
9 39	18+3; 30−2	7·9 7·9	...	7·9	
9 50	30−1	8·0	7·9	7·95	
10 0	30−1	8·0	...	8·0	
10 10	=30	8·1	...	8·1	Slightly more yellow?
10 20	=30	8·1	...	8·1	
10 25	30+1	8·2	...	8·2	Slightly orange yellow.
10 33	30+2; =29	8·3 8·3	8·3	8·3	Slight orange tint.
11 10	=22	9·4	9·4	9·4	Decided orange tint. Not so bright as 28.
11 30	=22	9·4	9·4	9·4	
11 40	... ...	...	9·4	9·4	Qu. 22 slightly brighter of the two −9·3?
12 48	22+0+1	9·4 9·5	9·4	9·4	
12 50	... ...	...	9·4	9·4	With 115 dull orange. With 191 both the small comites seen well 13^{h} 5^{m}.
13 10	... ...	...	9·4−	9·4	
13 20	... ...	...	9·4	9·4	
13 30	... ...	...	9·4	9·4	
13 48	... ...	...	9·3	9·3	Beginning to brighten up.
13 52	... ...	...	9·1	9·1	
13 58	=34	8·6	8·6	8·6	
14 0	=27	8·4	8·4	8·4	
14 3	30+2	8·3	8·3	8·3	
14 12	... ...	...	8·2	8·2	
14 18	30+1; 27−2	8·2 8·2	8·2	8·2	
14 27	=30	8·1	8·1	8·1	
14 32	Certainly *not less* than 30	...	...	8·1−?	
14 35	... ...	...	8·0	8·0	
14 40	18+3 30−2	7·9 7·9	7·9	7·9	So in large telescope. U bluish white.
1881 April 7.					
8 15	Gauged 7·2	...	7·2	7·2	U bluish white; 18 ruddy orange.
1881 April 13. Minimum ($9^{m}\cdot4$) at 11^{h} 44^{m} G.M.T. $=11^{h}$ $53^{m}\cdot3$ Paris M.T.					
10 5	27+1; 34−1	8·5 8·5	...	8·5	The early part of the evening cloudy.
10 15	=34	8·6	...	8·6	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
	1881 April 13—*continued.*				
h m					
10 20	34+2	8·8	...	8·8	
10 27	... ...	...	9·2	9·2	With 115 orange tint. Moonlight and light haze.
10 33	About = 22 22 − 1 ? ...	9·4 9·3	...	9·35	
10 36	= 22	9·4	...	9·4	
10 40	= 22	9·4	...	9·4	
11 43	22 + 0 + 0·5	9·4 9·45	9·5 9·5−	9·45	
11 51	= 22	9·4	...	9·4	
12 38	= 22	9·4	...	9·4	Clouds from $12^h\ 25^m - 12^h\ 38^m$.
12 42	= 22	9·4	...	9·4	In clear interval between clouds.
12 44	= 22	9·4	...	9·4	
12 48	= 22	9·4	...	9·4	Not brighter than 22.
12 59	22 − 1	9·3	...	9·3	Certainly slightly brighter than 22.
13 5	22 − 3; 34 + 5	9·1 9·1	...	9·1	
13 10	34 + 4; 22 − 4	9·0 9·0	...	9·0	
13 15	= 34	8·6	...	8·6	
13 21	= 27	8·4	...	8·4	Clouds coming over. Wind S.E. still.
13 27	27 − 1 ? 30 + 2 ?	8·3? 8·3?	...	8·3?	Among clouds.
13 34	30 + 2; 27 − 1	8·3 8·3	...	8·3	
13 38	U not yet = 30	...	...	...	
13 55	= 30 ? not less ?	8·1 ?	...	8·1	Among clouds.
					Clouds came over hopelessly. Waited for a chance clear space in vain till $14^h\ 30^m$.
	1881 April 28. Minimum $9^m{\cdot}4$ at $10^h\ 38^m \pm$ G.M.T. = $10^h\ 47^m{\cdot}3$ Paris M.T.				
8 10	18 + 4; 30 − 1	8·0 8·0	...	8·0	Doubtful observation. Full twilight.
8 21	= 30	8·1	...	8·1	Sky not clear.
8 24	= 30	8·1	...	8·1	Light clouds over sky.
8 27	U certainly less than 30	8·1 +	...	8·1 +	A glimpse, rather doubtful.
8 37	30 + 1; 27 − 2	8·2 8·2	...	8·2	A clear interval between clouds. Circumstances bad for observation.
8 45	= 29; 30 + 2	8·3 8·3	...	8·3	So in finder too.
8 50	= 27; 34 − 2	8·4 8·4	...	8·4	
8 57	= 27	8·4	...	8·4	A good observation in tel. and finder.
9 2	27 + 1; 34 − 1	8·5 8·5	...	8·5	Estimated so in tel. and also in finder.
9 24	= 34	8·6	...	8·6	
9 30	34 + 4; 22 − 4	9·0 9·0	...	9·0	
9 35	34 + 6; 22 − 2	9·2 9·2	...	9·2	
9 40	= 22	9·4	...	9·4	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
		1881 April 28—*continued.*			
h m					9^h 50^m to 11^h 50^m cloud and haze. Observation impossible.
12 10	= 34; less than 27 ...	8·6 ± 8 5	...	8·55	A brief glimpse. Very doubtful.
12 25	30 + 2?	8·3?	...	8·3?	A brief glimpse.
12 50	30 − 1? 30 − 0? in finder = 30	8·0 8·1 8·0	...	8·0	Well seen in a clear interval lasting for a few seconds.
13 10	U several tenths > 30 nearly = 18?	8·1 − 7·6 +	...	7·8?	U bluish white. 18 ruddy orange.
	The observation of this minimum has been difficult from the cloud and haze which have been so prevalent.				
	1881 May 3. Minimum ($9^m·4$) at 10^h 23^m G.M.T. = 10^h $32^m·3$ Paris M.T.				
8 9	30 + 1 + 0·5 + 0; 27 − 2 − 25	8·2 8·15 8·1 8·2 8·15	...	8·15	Full twilight.
8 20	30 + 1·5; 27 − 1·5 ...	8·25 8·25	...	8·25	
8 29	= 27	8·4	...	8·4	In the twilight I think that 29 is certainly *not* brighter than 27.
8 32	= 27	8·4	...	8·4	So, too, in finder.
8 38	27 + 1; 34 − 1	8·5 8·5	...	8·5	
8 47	27 + 2; = 34	8·6 8·6	...	8·6	U pale orange tint? Not very decided.
9 0	34 + 2; 27 + 4	8·8 8·8	...	8·8	
9 5	34 + 4 + 5	9·0 9·1	...	9·05	
9 10	22 − 2; 34 + 6	9·2 9·2	...	9·2	
9 15	22 − 1	9·3	...	9·3	U slightly brighter of the two.
9 18	= 22?	9·4?	...	9·4?	
9 20	Certainly = 22	9·4	...	9·4	In finder and in tel. Sky rather hazy.
9 22	Certainly not > 22				
10 25	= 22; 22 + ?	9·4 9·4 + ?	...	9·4	Certainly *not* < 22. Slight ruddy orange tint; tel. powers 70 and 89.
11 13	= 22	9·4	...	9·4	
11 20	= 22	9·4	...	9·4	
11 25	= 22	9·4	...	9·4	$U = \frac{1}{2}(30 + 26) = \frac{1}{2}(8·1 + 10·7) = 9·4.$
11 33	22 − 1?	9·3?	...	9·3?	
11 37	22 − 2	9·2	...	9·2	
11 42	22 − 4; 34 + 4	9·0 9·0	...	9·0	
11 48	22 − 5; 34 + 3	8·9 8·9	...	8·9	Light of U a little unsteady? Orange tint?
11 51	= 34	8·6	...	8·6	
11 53	34 − 1; 27 + 1	8·5 8·5	...	8·5	
11 55	= 27	8·4	...	8·4	In tel. and finder.
12 0	30 + 2; 27 − 1	8·3	...	8·3	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
	1881 May 3—*continued.*				
h m					
12 10	½ (30 + 27)	8·25	...	8·25	
12 15	30 + 1 ; 27 − 2	8·2	...	8·2	
12 28	= 30	8·1	...	8·1	
12 30	= 30	8·1	...	8·1	Careful comparison in tel. and finder. So too with discs out of focus. U bluish white. 12^h 12^m both gauged 8·1.
12 45	30 − 1	8·0	...	8·0	Bluish white.
12 50	30 − 2	7·9	7·9	7·9	
	1881 May 8 (Sunday.) Minimum (9^m·4) at 10^h 1^m G.M.T. = 10^h 10^m·3 Paris M.T.				
8 29	34 + 2 ; 22 − 6	8·8 8·8	...	8·8	A fine clear night. Decided orange tint. Full colour. Full twilight.
8 36	34 + 4 ; 22 − 4	9·0 9·0	...	9·0	Observation rather difficult in full twilight.
8 44	34 + 5 ; 22 − 3	9·1 9·1	...	9·1	
8 49	34 + 6 ; 22 − 2	9·2 9·2	...	9·2	
8 54	34 + 7 ; 22 − 1	9·3 9·3	...	9·3	
8 57	= 22	9·4	9·4	9·4	
9 5	= 22	9·4	...	9·4	
9 48	22 + 0 + 1	9·4 9·5	9·4	9·4	Fine orange tint. Bright moonlight.
10 46	= 22	9·4	9·4	9·4	Light a little unsteady? Orange tint.
11 0	= 22	9·4	9·4	9·4	
11 7	= 22	9·4	...	9·4	Light unsteady.
11 12	22 − 1	9·3	...	9·3	
11 15	22 − 2	9·2	9·2	9·2	
11 18	34 + 4 ; 22 − 4	9·0 9·0	9·0	9·0	
11 24	= 34	8·6	8·6	8·6	
11 30	34 − 1 ; 27 + 1	8·5 8·5	8·5	8·5	
11 35	27 − 1 ; = 29	8·3 8·3	8·3	8·3	
11 39	... ...	...	8·3	8·3	Slightly orange yellow.
11 43	30 + 1	8·2	...	8·2	
11 50	30 + 1	8·2	...	8·2	
12 0	Barely = 30	8·15	...	8·15	Light rather unsteady.
12 5	= 30	8·1	8·1	8·1	
12 12	30 − 1	8·0	...	8·0	
12 15	30 − 1	8·0	8·0	8·0	
12 20	30 − 2	7·9	7·9	7·9	White or very pale yellow.
12 30	... ...	...	7·8	7·8	
12 45	= 18	7·6	7·6	7·6	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. Gauged.	Mean Mag.	Remarks.
1881 August 6.					
h m 10 50	... ...	...	7·1	...	
1881 September 27 (Tuesday).					
7 0	... ...	...	7·1	7·1	
8 38	... ...	...	7·1	7·1	
9 0	... ...	...	7·1·2	7·1·2	White.
9 45	=30	8·1	...	8·1	
9 53	=30	8·1	...	8·1	Slightly orange yellow? Hazy sky.
10	30+1	8·2	8·2	8·2	
10 5	30+1; 29 (8·3)−1 ...	8·2 8·2	...	8·2	
10 15	30+2; =29	8·3 8·3	8·3	8·3	Slight orange tint?
10 22	=27	8·4	8·4	8·4	
10 25	=27	8·4	...	8·4	60 and var. 30 hidden behind bar of eyepiece. Orange tint.
10 36	27+1	8·5	...	8·5	
10 41	30+6; 22−7	8·7 8·7	...	8·7	Ruddy slightly. A hazy sky. Observation difficult.
10 48	27+4	8·8	...	8·8	
10 52	27+5; 22−5	8·9 8·9	...	8·9	
10 59	27+6; 22−4	9·0 9·0	...	9·0	
11 3	22−3	9·1	...	9·1	
11 9	22−2	9·2	...	9·2	Brighter decidedly than 22. Too hazy and uncertain for gauging.
11 17	22−2	9·2	...	9·2	A cloudy interval $11^h\ 30^m$–$12^h\ 30^m$.
12 32	22−2−3...	9·2 9·1	...	9·15	Cloudy; observation doubtful.
					Watched till $13^h\ 30^m$, but hopeless clouds prevented any further observation. Apparently no chance of clearing.
1881 October 2 (Sunday). Minimum ($9^m·2$) at $11^h\ 47^m$ G.M.T. = $11^h\ 56^m$ 3 Paris M.T.					
8 30	... ...	...	7·3	7·3	U white.
8 44	... ...	...	7·4 7·3	7·3	
8 54	... ...	...	7·4	7·4	
9 4	... ...	...	7·5?	7·5?	
9 9	=18	7·8	7·8	7·8	
9 16	30−0−1...	8·1 8·0	...	8·05	
9 55	30+2; 27−1	8·3 8·3	...	8·3	Yellow.
10 0	=27	8·4	...	8·4	Orange yellow, or buff colour.

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
	1881 October 2—*continued.*				
h m					
10 5	27 + 1	8·5	...	8·5	
10 12	27 + 3	8·7	8·7	8 7	
10 21	27 + 6 ; 22 − 4	9·0 9·0	9·0	9·0	
10 25	... ...	...	9·0 9·1	9·05	
10 31	28 − 1 ; 22 − 3	9·1 9·1	...	9·1	Clear moonlight. Certain wind N.E.
10 41	= 28 ; 22 − 2	9·2 9·2	9·2	9 2	
10 47	= 28 ; 22 − 2	9·2 9·2	9·2	9·2	
12 25	= 28 ; 22 − 2	9·2 9·2	9·2	9·2	Orange yellow. 70 and 115 decidedly 22 ∴ > 9·4.
12 40	... ...	...	9·2	9·2	
12 54	= 28	9·2	9·2	9 2	Light a little unsteady?
13 6	28 − 1 ?	9·1?	9·1?	9·1?	Slightly brighter than it was?
13 11	... ...	...	9·0	9·0	Certainly > 28.
13 20	... ...	...	8·8 8·9	8·85	
13 25	27 + 2 + 3	8 6 8·7	8·7·6	8 65	
13 31	= 27 ; 27 + ?	8·4	8·4	8·4	Ruddy yellow.
13 38	= 27	8·4	8·4	8·4	
13 45	= 29 ; 27 − 1 ; 30 + 2 ...	8·3 8·3 8·3	8·3	8·3	
14 0	30 + 1 + 2	8·2 8·3	...	8·25	
14 9	= 30	8·1	...	8·1	Rather more yellow than 30.
	1881 October 17 (Monday). Minimum ($9^{m}·2$) at 10^{h} 44^{m} G.M.T. = 10^{h} $53^{m}·3$ Paris M.T.				
6 30	... ...	...	7·1	...	30 gauged 8·1, 18 = 30 8·1.
7 56	= 30	8·1	8·1	8·1	
8 3	= 30	8·1	...	8·1	
8 10	= 30	8·1	8·1	8·1	
8 17	30 + 1	8·2	...	8·2	Barely as bright as 30.
8 25	30 + 1	8·2	...	8·2	Yellow tint?
8 38	= 29	8·3	8·3	8·3	
8 50	= 27	8·4	8·4	8·4	
9 0	... ...	...	8·5	...	Light a little unsteady.
9 2	27 + 1	8·5	8·5	8·5	
9 35	22 − 2	9·2	9·2	9·2	
9 44	22 − 2	9·2	9·2	9·2	Orange tint.
10 8	22 − 2	9·2	9·2	9·2	U certainly a tenth or two brighter than 22.
10 45	22 − 2 − 1	9·2 9·3	9·2	9·2	Certainly rather brighter than 22.
11 39	22 − 1	9·3	9·2 9·3	9·3	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
	1881 OCTOBER 17—*continued.*				
h m					
11 43	... ...	...	9·2	9·2	
11 52	... ...	...	9·2	9·2	With 115 slightly orange yellow.
11 59	... ...	...	9·1	9·1	
12 2	... ...	...	9·0	9·0	
12 10	... ...	...	8·8	8·8	
12 15	27+3	8·7	8·7	8·7	Equal intervals between 30 and 27 and 27 and U.
12 25	=27	8·4	...	8·4	
12 27	=27 ; 27 − ?	8·4	8·4	8·4	
12 33	... ...	...	8·4	...	Light rather unsteady.
12 40	... ...	...	8·3	8·3	
12 50	30+1 ; 27−2	8·2 8·2	...	8·2	Light unsteady.
13 8	=30	8·1	...	8·1	
13 10	Certainly=30	8·1	...	8·1	In large telescope and in finder.
	1881 NOVEMBER 21 (Monday).				
6 30	30+3=27	8·4 8·4	...	...	Clouds with a S.W. wind. Further observation impossible.
	1881 DECEMBER 21 (Wednesday). Minimum ($9^m{\cdot}25$) at 6^h 24^m G.M.T. = $6^h 33^m{\cdot}3$ Paris M.T.				
5 6	22−4 ; =28?	9·0 9·0	...	9·0	
5 20	22−2 ; 28+2	9·2 9·2	...	9·2	
5 24	22−2	9·2	...	...	
5 27	22−2	...	...	...	
6 40	22−2−1...	...	9·3	...	
6 47	22−2	...	9·2 9·3	...	
7 2	22−2 ; 28+2	9·2 9·2	...	...	U orange tint.
7 15	22−2 ; 28+2	...	9·2 9·3	...	
7 28	=28 ; 22−3−4... ...	...	9·1	...	
7 39	28+2 ; 22−2	...	...	...	
8 16	=27	8·4	...	...	
8 22	=29	8·3	...	...	
8 35	=30	8·1	...	...	
8 54	30−1	8·0	8·0	...	
9 1	30−1	8·0	8·0	...	
9 57	30−2	8·0	7·8	...	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1882 March 18 (Saturday). Minimum mag. ($9^{m}\cdot5$) at 12^{h} 21^{m} G.M.T. $=12^{h}$ $30^{m}\cdot3$ Paris M.T.					
h m					
9 45	U = 30	...	...	...	
9 50	= 30	8·1	8·1	8·1	
10 5	30 + 1 ?	8·2 ?	...	8·2	Slight yellow tint ?
10 12	30 + 0 + 1	8·1 8·2	...	8·15	
10 28	30 + 2	8·3	8·3	8·3	
10 38	... ...	...	8·4	8·4	
10 51	... ...	...	8·6	8·6	Orange yellow tint.
10 55	... ...	...	8·7	8·7	
11 2	... ...	...	9·0	9·0	
11 5	= 22	9·4	9·4	9·4	Buff yellow.
11 10	22 + 1	9·5	9·5	9·5	
11 15	22 + 1 ?	9·5 ?	9·5	9·5	A fine, still night.
11 20	... ...	...	9·5	9·5	
11 57	22 + 1 ?	9·5	9·5	9·5	
12 56	... ...	...	9·5	9·5	Orange tint.
13 3	... ...	...	9·5	9·5	(The two comites of U 11·12 12·13 mag. well seen with 191.)
13 8	... ...	...	9·5	9·5	
13 16	22 + 1	9·5	9·5	9·5	
13 20	... ...	...	9·5	9·5	[26 well seen in 2 in. finder. $10^{m}\cdot7$?]
13 26	... ...	...	9·5	9·5	
13 38	= 22	9·4	9·4	9·4	Beginning to brighten up ?
13 45	22 − 2	9·2	9·2	9·2	Very decidedly brighter.
13 50	... ...	...	9·0	9·0	Rapidly brightening up.
14 0	34 + 1 ?	8·7	8·7	8·7	
14 6	= 27	8·4	...	8·4	
14 11	... ...	...	8·3	8·3	
14 15	30 + 2	8·3	8·3	8·3	
1882 April 7 (Friday). "Good Friday," clear and bright, a cool N.E. wind. Minimum ($9^{m}\cdot45$) at 11^{h} 5^{m} G.M.T. $=11^{h}$ $14^{m}\cdot3$ Paris M.T.					
7 37	= 18 ; 30 − 6 ?	7·5 7·5	...	7·5	Full twilight.
7 50	18 + 1 ; 30 − 5	7·6 7·6	7·6	7·6	18 gauged 7·5 ruddy.
7 56	... ...	...	7·6	7·6	U white.
8 5	18 + 4 ; 30 − 2	7·9 7·9	7·9	7·9	
8 12	... ...	...	7·9	7·9	
8 19	18 + 4 ; 30 − 2	7·9 7·9	7·9	7·9	
8 23	30 − 1	...	...	8·0	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1882 April 7 (Friday)—*continued.*					
h m					
8 37	=30	8·1	8·1	8·1	
8 54	30+1	8·2	...	8·2	Light unsteady, colour yellowish.
9 4	30+1·5; 27−1·5 ...	8·25 8·25	...	8·25	
9 27	27+1	8·5	...	8·5	Yellow.
9 39	... ...	...	9·2	9·2	
9 42	=22	9·4	9·4	9·4	Dull yellow, pale.
9 45	22+1	9·5	...	9·5	
9 49	... ...	...	9·5	9·5	
9 50	22+1+0	9·5 9·4	...	9·45	
9 55	22+1	9·5	...	9·5	
10 30	22+0+1	9·4 9·5	...	9·45	
10 53	22+0+1	9·4 9·5	...	9·45	
10 56	22+1	9·5	...	9·5	Buff yellow.
11 57	22+1	9·5	9·5	9·5	
12 11	22+1	9·5	9·5	9·5	
12 21	22+0	9·4	9·4	9·4	Beginning to brighten up?
12 27	22+0	9·4	...	9·4	
12 31	22+0	...	9·4	9·4	
12 32	22−1	9·3	...	9·3	
12 35	22−4	9·0	9·0	9·0	
12 38	=34	8·6	...	8·6	
12 41	=27	8·4	8·4	8·4	Rapidly brightening up.
12 45	... ...	...	8·3	8·3	
12 50	... ...	...	8·3	8·3	
12 55	27−1	8·3	8·3	8·3	
13 0	30+1	8·2	...	8·2	
13 5	30+1	8·2	...	8·2	
13 17	30+0	8·1	8·1	8·1	Bluish white.
13 24	30−2	7·9	7·9	7·9	The star did not, I think, attain at min. *quite* so low a mag. as on March 18, 9·45 say.
1882 April 22 (Saturday). Minimum ($9^{m}\cdot5$) at $10^{h}\ 5^{m}$ G.M.T. $=10^{h}\ 14^{m}\cdot3$ Paris M.T.					
8 25	=34−1	8·5	8·5	8·5	
8 31	=34	8·6	8·6	8·6	
8 37	34+4; 22−4	9·0 9·0	9·0	9·0	
8 40	... ...	...	9·2	9·2	
8 43	22−1	9·3	9·3	9·3	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1882 April 22 (Saturday)—*continued.*					
h m					
8 44	=22	9·4	9·4	9·4	Decided ruddy, orange tint.
8 48	22+0+1	9·4 9·5	...	9·45	18 decidedly ruddy.
8 50	22+0+1	9·4 9·5	9·5	9·5	
9 0	22+1	9·5	9·5	9·5	Very distinct, ruddy orange. 18 full yellow with orange tinge.
9 14	22+1	9·5	9·5	9·5	
9 54	22+1	9·5	9·5	9·5	A slightly fainter min. than that of April 7, I think.
10 16	22+1	9·5	9·5	9·5	
10 55	22+1	9·5	9·5	9·5	
11 0	22+1	9·5	9·5	9·5	
11 6	22+1	9·5	9·5	9·5	
11 12	22+1	9·5	9·5	9·5	U decidedly ruddy.
11 18	22+0+1	9·4 9·5	9·45	9·45	Beginning to brighten up ??
11 24	=22?	9·4?	9·4?	9·4	
11 30	=22?	9·4?	...	9·4?	Clouds troublesome.
11 33	22−1−2	9·3 9·2	...	9·25	Certainly rather > 22.
Observation interrupted by cloud (with S.W. wind), which remained hopelessly persistent up to 12 o'clock, when the watch was discontinued.					
1882 April 27 (Thursday). Minimum ($9^{m}·45$) at 9^{h} 45^{m} G.M.T. = 9^{h} $54^{m}·3$ Paris M.T.					
8 9	31+5=34	8·6 8·6	...	8·6	Bright twilight and rather cloudy.
8 16	34+2; 22−6	8·8 8·8	...	8·8	In large telescope. Very doubtful observation. Clouds troublesome.
8 21	½(34+22)	9·0 9·0	...	9·0	Most doubtful observation. Clouds.
8 25	22−2?	9·2?	...	9·2?	Among clouds. Very doubtful.
8 29	=22	9·4	...	9·4	Fair observation.
8 45	22+0+1	9·45	...	9·45	Clear sky now.
9 0	22+1	9·5	9·5	9·5	
9 48	22+0+1	9·4 9·5	...	9·45	
10 0	22+1+0	9·5 9·4	9·5	9·5	
10 46	22+0−1	9·4 9·5	...	9·45	
10 48	22+0·5	9·45	...	9·45	
10 50	22+0·5	...	...	9·45	
10 56	=22	9·4	9·4	9·4	
10 59	=22	9·4	...	9·4	
11 2	=22	9·4	9·4	9·4	Orange ruddy.
11 4	22−1	9·3	...	9·3	
11 6	... ...	...	9·0	9·0	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1882 April 27 (Thursday)—*continued.*					
h m					
11 8	=34	...	...	8·6	
11 12	=27	8·4	8·4	8·4	
11 18	27−1	8·3	...	8·3	Clouds a little troublesome.
11 20	27−1	8·3	...	8·3	
11 24	30+2; 27−1	8·3 8·3	...	8·3	Yellow.
11 28	30+1; 27−2	8·2 8·2	...	8·2	
11 38	30+1; 27−2	8·2	...	8·2	
11 50	=30	8·1	...	8·1	Barely so white as 30?
11 53	=30	8·1	...	8·1	U certainly as bright as 30?
11 56	=30	8·1	...	8·1	
12 0	=30−?	...	...	8·05?	
1882 October 31 (Tuesday). Minimum ($9^{m}·2$) at 8^{h} 40^{m} G.M.T. = 8^{h} $49^{m}·3$ Paris M.T.					
6 58	30+2; =29	8·3 8·3	...	8·3	A clouded sky.
7 18	29+3	...	...	8·6	A glimpse between clouds.
7 25	34+4; 22−4	9·0 9·0	...	9·0	
7 38	22−2	9·2	...	9·2	A glimpse between clouds.
7 46	22−2	9·2	...	9·2	Certainly brighter than 22.
8 6	22−2	9·2	...	9·2	
8 26	22−2	9·2	...	9·2	Certainly brighter than 22.
8 42	22−2−3	...	...	9·2	Decidedly brighter than 22. So, too, in finder. 18=30−1?
9 2	22−2	...	...	9·2	
9 58	34+3; 22−4	8·9 9·0	...	8·9	8·8 9·0 est. (a brief, clear interval).
10 8	34+2	...	...	8·8	
10 15	=34?	...	...	8·6?	
10 19	27+2; =34	8·6 8·6	...	8·6	Ruddy?
10 26	27+1; 34−1	8·5 8·5	...	8·5	
10 38	=27	...	...	8·4	
The observations of this minimum were made with difficulty. The stars were caught in short, clear intervals between clouds, and their light estimates are doubtful.					
1882 November 20 (Monday).					
6 20	22−3	9·1	...	9·1	
6 37	22−3−2	9·1 9·2	9·1	9·1	A hazy sky.
6 49	22−2	9·2	...	9·2	
7 44	22−2−3	9·2 9·1	9·1	9·1	Observation among clouds.
8 8	... ...	...	9·1	9·1	Orange yellow.
8 20	22−2−3	9·2·1	...	9·15	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1882 November 20 (Monday)—*continued.*					
h m					
8 23	... ...	...	9·1	9·1	
8 34	... ...	...	9·1	9·1	
8 39	22−3−4	9·1 9·0	9·0	9·0	
8 45	... ...	...	9·0	9·0	
8 52	... ...	...	8·8	8·8	
8 59	34+1	8·7	8·7	8·7	
9 2	=34	8·6	...	8·6	
9 8	34−1	8·5	8·5	8·5	
9 12	=27	8·4	...	8·4	
9 14	=27?	8·4	...	8·4	
9 59	=30; 30+1	8·1 8·0	...	8·05	Light clouds troublesome.
November 30 (Thursday) (??). Doubtful Observation. Minimum ($9^{m}\cdot1$) at 6^{h} 41^{m} G.M.T. = 6^{h} $50^{m}\cdot3$ Paris M.T.					
5 24	34+3 22−5	8·9 8·9	...	8·9	
5 28	... ...	...	9·0	9·0	
6 8	22−3	9·1	9·1 9·2	9·1	
6 15	... ...	...	9·1	...	
6 32	22−3	9·1	9·1	9·1	
7 58	22−5	8·9	8·9	8·9	18 ruddy.
8 0	... ...	...	8·9	8·9	
8 9	34+2	8·8	8·8	8·8	
8 12	... ...	...	8·8	8·8	
8 17	... ...	...	8·7	8·7	
8 30	... ...	...	8·6	8·6	
8 34	=27	8·4	8·4	8·4	
8 37	=29	8·3	8·3	8·3	
8 49	30+1	8·2	...	8·2	
8 58	=30	8·1	8·1	8·1	
9 7	=30	8·1	...	8·1	
9 58	30−4	...	...	7·7	
1883 March 2 (Friday). Minimum ($9^{m}\cdot45$) at 12^{h} 36^{m} G.M.T. = 12^{h} $45^{m}\cdot3$ Paris M.T.					
7 25	... ...	...	7·2	7·2	U white. 18 orange tint. 22 9·4.
7 48	... ...	...	7·2	7·2	34 8·6 ruddy orange.
8 0	... ...	...	7·2	7·2	
8 31	... ...	...	7·3	7·3	
8 36	=18	7·4	7·4	7·4	White.
8 41	=18	7·4	7·4	7·4	
8 45	18+2; 30−5	7·6 7·6	7·6	7·6	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags	Mag. gauged.	Mean Mag.	Remarks.
1883 March 2 (Friday)—*continued.*					
h m					
8 50	18+1+2?	7·5 7·6	7·5 7·6	7·55	
8 58	... ...	...	7·6	7·6	
9 5	... ...	...	7·8	7·8	
9 20	30−2 18+5	7·9 7·9	7·9	7·9	
9 40	30·2	7·9	7·9	7·9	
10 8	=30	...	...	8·1	
10 15	=30	8·1	8·1	8·1	U slightly yellow in tint? (110).
10 31	30+0+1	8·1 8·2	...	8·15	
10 42	=29	8·3	8·3	8·3	
10 55	... ...	...	8·5	8·5	
11 0	=34	8·6	8·6	8·6	Slight orange tint?
11 10	... ...	...	8·7	8·7	
11 15	... ...	...	9·0	9·0	
11 21	=22	9·4	9·4	9·4	
11 24	22+0+1	9·4 9·5	9·5	9·5	Orange tint (110).
11 30	22+0+1	9·4 9·5	9·4 9·5	9·45	Certainly not brighter than 22.
11 40	22+0+1	9·4 9·5	9·4 9·5	9·45	
13 2	22+0+1	9·4 9·5	9·4 9·5	9·45	Yellow. Hardly so decided a tint as sometimes?
13 17	22+0·5	9·45	...	9·45	
13 25	22+0+1	9·45	9·45	9·45	
13 35	22+0+1	9·45	9·45	9·45	
13 45	22+0·5	...	...	9·45	
13 50	=22	...	...	9·4	
13 55	22−4	...	...	9·0	
14 0	... ...	...	8·8	8·8	
14 3	... ...	...	8·6	8·6	
14 5	29+1	8·4	8·4	8·4	
14 10	=29	8·3	8·3	8·3	
14 20	30+1 29−1	8·2 8·2	8·2	8·2	
14 30	=30	8·1	8·1	8·1	
1883 March 12 (Monday). Minimum ($9^m·4$) at $11^h\ 49^m$ G.M.T. = $11^h\ 58^m·3$ Paris M.T.					
7 42	... ...	...	7·4 7·3	7·35	
7 50	=18	7·35	7·3 7·4	7·35	
7 58	=18	7·4	7·4	7·4	
8 0	=18	7·4	7·4	7·4	
8 3	=18	7·4	7·4	7·4	
8 20	18+2	7·6	7·6	7·6	White.

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
	1883 March 12 (Monday)—*continued.*				
h m					
8 40	18+4; 30−3	7·8 7·8	7·8	7·8	
8 51	18+5; 30−2	7·9 7·9	7·9	7·9	White as 30.
9 2	30−2	7·9	7·9	7·9	White.
9 38	=30	8·1	...	8·1	
9 45	30+1	8·2	...	8·2	Yellow or slight orange tint? (110).
9 53	30+2; 27−1	8·3 8·3	...	8·3	
9 55	=27	8·4	8·4	8·4	Orange tint.
10 6	27+1	8·5	8·5	8·5	Decided orange tint, but not so ruddy as 34.
10 16	=34	8·6	...	8·6	8·6 gauged.
10 26	... ...	...	8·9	8·9	
10 30	... ...	...	9·0	9·0	
10 33	=22	9·4	9·4	9·4	Decided ruddy orange.
10 37	=22	9·4	9·4	9·4	
11 3	=22	9·4	9·4	9·4	
12 33	=22	9·4	9·4	9·4	
12 58	=22	9·4	...	9·4	Orange tint (60) 18 and 30 concealed by bar in eyepiece.
13 7	22−1−2...	9·3 9·2	9·2	9·2	
13 10	22−4	9·0	9·0	9·0	
13 14	=34	8·6	8·6	8·6	
13 21	=27	8·4	8·4	8·4	
13 24	30+2	8·3	...	8·3	Yellow, not orange now (110).
13 30	30+2=29	8·3 8·3	8·3	8·3	
13 39	30+1	8·2	...	8·2	Clear yellow. 30 white.
13 47	=30	8·1	...	8·1	White.
13 50	=30	8·1	8·1	8·1	
13 56	30−1	8·0	8·0	8·0	
	1883 March 22 (Thursday). Minimum ($9^{m}·45$) at 11^{h} 10^{m} G.M.T. = 11^{h} $19^{m}·3$ Paris M.T.				
7 20	18−1	7·4	7·4	7·4	Twilight and moonlight.
8 0	30−3	7·8	7·8	7·8	30 gauged 8·1.
8 15	30−2	7·9	7·9	7·9	
8 21	30−1	8·0	...	8·0	Light a little unsteady at times?
8 32	=30	8·1	...	8·1	
8 35	=30	8·1	...	8·1	Colour white, like 30. (110 e.p.)
8 40	30−1	8·0	8·0	8·0	Careful observation in finder and in tel.
8 50	=30	8·1	8·1	8·1	Certainly not brighter, I think, than 30 now.
9 0	30+2=29	8·3 8·3	8·3	8·3	Slightly more yellow than 30?
9 5	... ...	...	8·3	8·3	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1883 March 22 (Thursday)—*continued.*					
h m					
9 36	=34	8·6	...	8·6	
9 50	=34	8·6	...	8·6	Clouds troublesome.
9 54	=28	9·0	...	9·0	Doubtful. Among clouds.
9 56	=22	9·4	...	9·4	Decided orange tint (70). Clear interval between clouds.
10 1	=22	9·4	9·4	9·4	22 gauged 9·4. U orange tint.
10 3	22+0+1?	9·4 9·5	9·45	9·45	
10 8	22+0+1...	9·4 9·5	9·5−	9·45	Certainly not brighter than 22.
11 46	=22	9·4	...	9·4	View between clouds.
11 50	22+0+1...	9·4 9·5	...	9·45	Barely = 22.
11 56	22+0+1...	...	...	9·45	
12 4	=22	...	...	9·4	Observation a little doubtful. Not > 22.
12 17	=22?	...	...	9·4?	Doubtful.
12 28	... ...	...	...	9·2??	A short glimpse.
12 31	=34?	...	...	8·6?	Seen for a short time in tel. and in finder.
12 35	34−2? =27?	...	...	8·4?	
12 37	... ...	...	...	8·4?	
12 39	=27	...	...	8·4	A fair estimation.
12 44	30+2	...	...	8·3	A pretty good estimate.
12 51	30+2; 27−1	8·3 8·3	...	8·3	
13 1	30+1?	...	...	8·2?	
13 5	=30?	...	...	8·1?	
A strong E. wind driving over heavy clouds, with occasional bright spaces between, in which stars were well seen for a brief interval. The observation of ascending curve difficult and doubtful.					
1883 April 1 (Sunday). Minimum ($9^{m}·45$) at 10^{h} 29^{m} G.M.T. = 10^{h} $38^{m}·3$ Paris M.T.					
8 22	30+0+1...	8·1 8·2	...	8·15	
8 26	30+0+1...	8·1 8·2	8·1	8·15	
8 30	30+2	8·3	8·3	8·3	Slight orange tint.
8 40	30+3; 29+1; =27 ...	8·4 8·4 8·4	8·4	8·4	
8 44	27+1	8·5	8·5	8·5	
8 52	=34	8·6	8·6	8·6	
8 54	=34	8·6	...	8·6	Slight orange tint? not very marked. 34 decidedly ruddy.
9 0	34+4	9·0	9·0	9·0	18 decidedly ruddy.
9 2	=22	9·4	9·4	9·4	
9 5	=22	9·4	9·4	9·4	
9 7	=22+0+1	9·4 9·5	...	9·45	
9 14	22+0+1...	9·4 9·5	9·45	9·45	Orange tint in tel.

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1883 April 1 (Sunday)—*continued.*					
h m					
10 18	22 + 1 + 0	9·4 9·5	9·45	9·45	Orange tint.
10 47	22 + 0·5	9·45	9·45	9·45	Orange, ruddy, dull.
10 54	22 + 0·5	9·45	...	9·45	Light a little unsteady?
11 0	22 + 0 + 1	9·45	...	9·45	
11 2	= 22	9·4	9·4	9·4	
11 3	22 + 0 + 1	9·45	...	9·45	
11 6	22 + 0·5	9·45	9·4	9·45	
11 12	22 + 0·5	9·45	...	9·45	
11 21	22 + 0·5	9·45	9·45	9·45	
11 30	22 + 0·5	9·45	9·45	9·45	
11 32	= 22	...	9·4	9·4	
11 39	= 22	9·4	9·4	9·4	
11 42	= 22	9·4	...	9·4	
11 46	= 22	9·4	9·4	9·4	
11 48	= 22	9·4	...	9·4	
11 50	= 22	9·4	...	9·4	
11 54	22 − 1	9·3	...	9·3	
11 56	... ...	...	9·2	9·2	
11 57	... ...	...	9·0	9·0	
11 59	... ...	...	8·6	8·6	
12 0	= 27	8·4	8·4	8·4	
12 4	= 29	8·3	8·3	8·3	Yellowish. Nearly white?
12 9	... ...	...	8·3	8·3	
12 12	30 + 1 ; 27 − 2	8·2 8·2	...	8·2	
12 24	= 30	8·1	...	8·1	
12 26	= 30	8·1	8·1	8·1	Certainly not less than 30.
12 30	... ...	...	8·05	8·05	Slightly > 30. White.
1883 October 20 (Saturday). Minimum ($9^{m}\cdot2$) at 8^{h} 34^{m} G.M.T. = 8^{h} $43^{m}\cdot3$ Paris M.T.					
6 10	30 + 1 ; 27 − 2	8·2 8·2	8·2	8·2	
6 17	30 + 0 + 1 ; 27 − 2 − 3 ...	8·1 8·2 8·2 8·1	8·15	8·15	Careful observation.
6 35	30 + 2	8·3	8·3	8·3	Slight orange?
6 42	30 + 2	8·3	8·3	8·3	
6 49	30 + 3 = 29 (8·4)	8·4 8·4	8·4	8·4	
7 1	30 + 3	8·4	8·4	8·4	
7 5	29 + 2 ; = 34	8·6 8·6	8·6	8·6	
7 12	= 28 ; 22 − 4	9·0 9·0	9·0	9·0	Dull orange tint.
7 15	28 + 1 ; 22 − 3	9·1 9·1	9·1	9·1	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
	1883 October 20 (Saturday)—*continued.*				
h m					
7 18	... ...	...	9·1	9·1	Three-tenths or so > 22.
7 27	22 − 2 ; 28 + 2 + 1 ...	9·2 9·2 9·1	9·1	9·15	
7 33	... ...	...	9·2	9·2	22 gauged 9·4. 22 certainly not so bright as U.
7 45	... ...	...	9·2	9·2	Both comites seen. The smaller one faint, and not very distinctly seen. U orange ruddy tint with 258.
7 50	... ...	...	9·2	9·2	
8 0	22 − 2 − 1 ?	9·2 9·3	9·2	9·2	
8 45	22 − 2 (22 gauged 9·4) ...	9·2	9·2	9·2	$8^h 0^m$. In the large telescope I am sometimes in doubt whether U is > 22, but in finder with aperture diminished the difference is evident.
9 17	... ...	...	9·2	9·2	
9 20	22 − 2	9·2	9·2	9·2	Decided orange tint.
9 30	28 + 2 ; 22 − 2	9·2 9·2	9·2	9·2	
9 36	... ...	...	9·2	9·2	Light a little unsteady?
9 42	22 − 2	9·2	9·2	9·2	
9 45	28 + 1 ; 22 − 3	9·1 9·1	9·1	9·1	Moving upwards?
9 50	= 28	9·0	9·0	9·0	
9 55	34 + 4 ; 22 − 4	9·0 9·0	9·0	9·0	
10 2	= 34	8·6	8·6	8·6	
10 8	= 29	8·4	8·4	8·4	Yellow. Not so orange as it was.
10 18	30 + 2	8·3	8·3	8·3	18 decidedly red. 7·9 ± gauged.
10 25	30 + 2	8·3	8·3	8·3	
10 42	= 30	8·1	8·1	8·1	Equal in tel. and in finder. 18 de- [cidedly red.
10 45	= 30	8·1	8·1	8·1	White.
11 0	30 − 1	8·0	8·0	8·0	Barely = 18 ??
	1884 February 29 (Friday). Minimum ($9^m{\cdot}4$) at $11^h 36^m$ G.M.T. = $11^h 45^m{\cdot}3$ Paris M.T.				
7 10	= 18	7·6	7·6	7·6	
8 14	18 + 3 ; 30 − 2	7·9 7·9	...	7·9	
8 35	18 + 3 ; 30 − 2	7·9 7·9	...	7·9	
8 49	18 + 4 ; 30 − 1	8·0 8·0	...	8·0	
9 10	= 30	8·1	...	8·1	
9 37	= 27	8·4	...	8·4	Orange tint.
9 58	27 + 1 ; 34 − 1	8·5 8·5	...	8·5	
10 4	= 34	8·6	...	8·6	
10 16	34 + 2 ; 28 − 2	8·8 8·8	...	8·8	
10 27	= 22	9·4	9·4	9·4	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1884 February 29 (Friday)—*continued.*					
h m					
10 29	=22	9·4	...	9·4	So too E.K. (Mrs. Knott), slightly ruddy tint. So E.K. independently.
11 15	=22	9·4	...	9·4	
12 20	=22	9·4	...	9·4	Qu. barely = 22 ?
12 30	=22	9·4	9·4	9·4	
12 36	=22	9·4	...	9·4	Decidedly ruddy in tint.
12 42	22−0−1 ?	9·4 9·3	...	9·35 ?	
12 48	22−0−1	...	...	9·35	
12 50	22−1	...	...	9·3	
12 54	... ...	...	9·2	9·2	
12 58	22−4	9·0	9·0	9·0	
13 0	... ...	...	8·7	8·7	
13 6	=27	8·4	...	8·4	
13 10	... ...	...	8·4	8·4	
13 12	... ...	...	8·3	8·3	Not ruddy now ?
13 24	=30	8·1	8·1	8·1	Bluish white.
13 30	=30	8·1	8·1	8·1	
13 36	30−0−1	8·0 8·1	...	8·05	
13 48	30−1	8·0	...	8·0	
A fine night. Still and clear.					
1884 March 10 (Monday).					
8 10	=30−0−1	8·1 8·0	...	8·05	A clouded sky.
8 14	=30	8·1	...	8·1	
8 20	30−1	8·0	...	8·0	Moonlight and clouds.
8 36	30+1	8·2	...	8·2	Slight orange tint ?
8 45	=27	8·4	...	8·4	
8 47	27−1	8·3	...	8·3	
8 56	=27	8·4	...	8·4	
9 6	27+1 34−1	8·5 8·5	...	8·5	
9 45	... ...	...	...	...	Sky clouded over. No further observations possible.
1884 March 15 (Saturday).					
8 20	30+1	...	...	8·2	Ruddy orange decidedly.
8 24	=30 ; 30+1 ?	...	...	8·15	Ruddy.
8 36	=27 ; 30+3	8·4 8·4	...	8·4	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1884 March 20 (Thursday). Minimum ($9^{m}\cdot45$) at 10^{h} 16^{m} G.M.T. = 10^{h} $25^{m}\cdot3$ Paris M.T.					
h m					
7 45	30−1	8·0	...	8·0	Slight orange tint?
7 55	30−1	8·0	...	8·0	
8 0	=30	8·1	...	8·1	
8 15	=27	8·4	...	8·4	
8 28	27+1 34−1	8·5 8·5	...	8·5	
8 36	=34	8·6	...	8·6	
8 54	22−2 28+2	9·2 9·2	...	9·2	
8 58	22+0+1	9·4 9·5	9·4 9·5	9·45	9·4 9·5 gauged.
9 0	22+0+1	9·4 9·5	9·4 9·5	9·45	
9 6	22+0+1	9·4 9·5	...	9·45	
10 24	22+0+1	9·4 9·5	...	9·45	
11 4	22+1	9·5	...	9·5	Ruddy orange. A decided tint.
11 6	22+0+1	9·4 9·5	...	9·45	
11 20	22+0+1	9·4 9·5	...	9·45	Ruddy tint very decided. Flying clouds about.
11 42	22−3?	9·1	...	9·1	Among clouds.
11 47	34−2 =27	8·4 8·4	...	8·4	Clouds cleared off.
11 50	27−1	8·3	8·3	8·3	Gauged 8·3.
11 55	$(27+30)\frac{1}{2}$	...	...	8·25	Clouds coming again.
12 11	... ...	...	...	...	Sky hopelessly clouded. No further observations possible.
1885 February 27 (Friday). Incomplete.					
8 0	30−0−1	8·1 8·0	...	8·05	White? Clear space between clouds.
8 17	30+1	8·2	...	8·2	Slight yellow orange tint? Clouds very troublesome.
8 30	30+1; 27−2−3 ...	8·2 8·2 8·1	...	8·2	Caught in clear interval.
8 40	30+3; =27	8·4 8·4	...	8·4	
8 52	27+0+1; 30+3+4 ...	8·4·5 8·4·5	...	8·45	
9 0	27+3	8·6	...	8·6	A cloudy interval.
9 35	=28? 22−3−4? ...	9·0? 9·0? 9·1?	...	9·0?	A brief, clear interval.
10 2	22−2? −0?	9·2? ·4?	...	9·2? ·4?	A brief glimpse, or =22?
10 27	22−2? −1? −0? ...	9·2 9·3? 9·4?	...	9·25? ·4?	A brief interval between persistent clouds.
10 30	... ...	...	...	...	Observatory closed. Clouds so persistent, and clear intervals so brief and rare, that observations are of little value.

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1885 March 14 (Saturday). Minimum ($9^m.45$) at 9^h 32^m G.M.T. $= 9^h$ $41^m.3$ Paris M.T.					
h m					
7 50	27 + 1 ; 34 − 1	8·5 8·5	...	8·5	
7 55	... ...	...	8·5	8·5	Ruddy.
7 57	= 34	8·6	8·6	8·6	
8 1	... ...	...	8·7 8·8	8·75	
8 5	34 + 4	9·0	9·0	9·0	
8 9	= 22	...	9·4	9·4	
8 12	= 22	...	9·4	9·4	
8 22	22 + 0 + 1	9·4 9·5	...	9·45	Orange tint.
9 0	22 + 1	9·5	...	9·5	Orange tint.
9 40	22 + 0 + 1	9·45	...	9·45	Decidedly ruddy. Two comites well seen.
9 47	22 + 0 + 1	...	...	9·45	
10 12	22 + 1	...	...	9·5	Decidedly ruddy orange.
10 18	... ...	...	9·45	9·45	
10 20	= 22 ; 22 + 1	9·4 9·5	...	9·45	
10 30	= 22	...	...	9·4	
10 42	= 22	...	...	9·4	
10 45	... ...	...	9·4	9·4	
10 48	= 22	...	...	9·4	Comet eyepiece. 38 mag. power.
10 55	= 22	...	9·4	9·4	" "
10 58	22 − 1	...	9·3	9·3	" "
11 0	22 − 2	...	...	9·2	" "
11 2	... ...	...	9·0	9·0	" "
11 6	... ...	...	8·8	8·8	" "
11 8	= 34	...	...	8·6	" "
11 13	= 27	...	8·4	8·4	" "
11 16	= 27	...	8·4	8·4	" Orange tint.
11 18	= 27	...	8·4	8·4	" "
11 22	30 + 2 ; 27 − 1	...	...	8·3	" "
11 25	30 + 1	...	8·2	8·2	70 mag. power U yellow.
11 36	= 30	...	8·1	8·1	White as 30.
1885 March 19 (Thursday.) Minimum ($9^m.45$) at 9^h 12^m G.M.T. $= 9^h$ $21^m.3$ Paris M.T.					
7 0	= 30	...	...	8·1	Full twilight.
7 6	30 + 1	...	...	8·2	So too in finder.
7 12	30 + 2 27 − 1	8·3 8·3	...	8·3	
7 13	= 27 30 + 3	8·4 8·4	...	8·4	Getting darker (70).
7 20	= 27	...	...	8·4	(38 mag. p. comet e.p.) and in finder.
7 25	27 + 1 31 + 4	...	...	8·5	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1885 March 19 (Thursday)—*continued.*					
h m					
7 27	=34	...	...	8·6	
7 33	34+2	...	...	8·8	
7 40	... ...	...	...	9·0	
7 45	22−2 28 (9·0)+2 ...	9·2 9·2	...	9·2	A hazy sky.
7 50	=22	...	...	9·4	
7 54	=22	...	...	9·4	(70).
8 0	=22	...	...	9·4	Hazy, but fairly seen. U ruddy.
8 2	22+0+1	...	...	9·45	
8 12	22+0+1	...	...	9·45	
8 52	22+1	...	...	9·5	(70).
9 0	22+1+0	...	...	9·45	(38).
9 6	22+0+1	...	...	9·45	
9 45	22+0+1	...	...	9·45	Ruddy.
9 49	22+1	...	...	9·5	
10 15	22+0+1	...	...	9·45	(38).
10 18	22+0+1	...	...	9·45	So too finder. U ruddy orange (70).
10 30	=22	...	...	9·4	
10 35	22−1	...	...	9·3	(70).
10 36	22−1−2	...	...	9·25	Ruddy orange, decided tint.
10 42	22−3 34+5	9·1 9·1	...	9·1	
10 45	... ...	...	9·0	9·0	
10 48	34−1 27+1	8·5 8·5	...	8·5	
10 52	=27	8·4	8·4	8·4	Orange yellow.
10 54	30+2=29 (8·3)	8·3 8·3	...	8·3	
11 0	30+2=29 27−1 ...	8·3 8·3 8·3	...	8·3	
11 3	... ...	...	8·3	8·3	
11 12	30+1 27−2	8·2 8·2	...	8·2	
11 16	=30	...	...	8·1	
11 19	30−1−0	8·0 8·1	...	8·05	
11 25	30−1−0	8·0 8·1	...	8·05	
11 36	30−1	...	...	8·0	White.
1885 August 13 (Thursday).					
9 25	=27	8·4	...	8·4	
10 5	... ...	...	...	9·0	
1887 January 26 (Wednesday). Minimum ($9^m·4$) at 10^h 45^m G.M.T. $=10^h$ $54^m·3$ Paris M.T.					
7 30	30−2	7·9	7·9	7·9	White. 18 ruddy 7·9? 7·8?
7 42	=30?	...	...	8·1	Slightly ruddy (38 mag. p.).

U Cephei—continued.

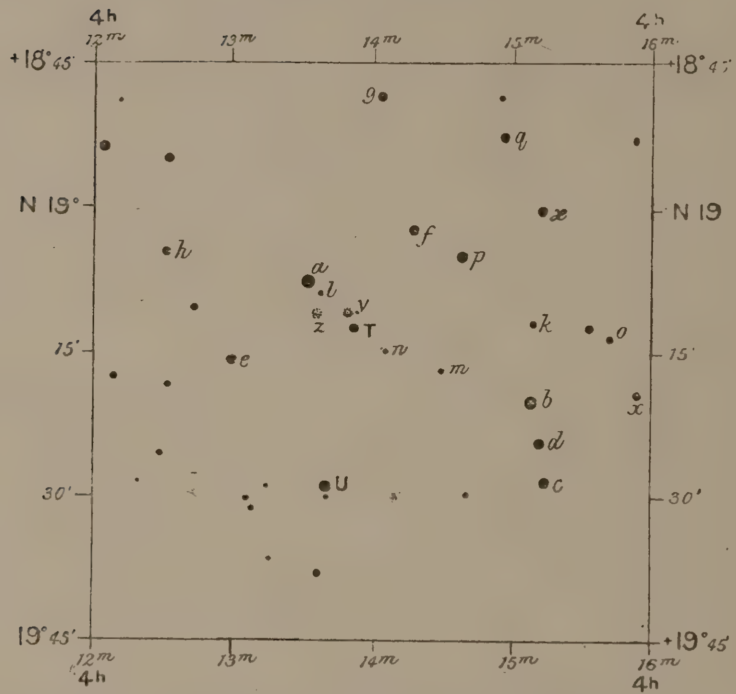
Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1887 January 26 (Wednesday)—*continued.*					
h m					
7 50	= slightly less than ? 30...	...	...	8·15	
8 0	= or slightly less than 30?	...	...	8·15	Slight orange tint.
8 15	30 + 1 29 (8·3) − 1 ...	8·2 8·2	...	8·2	Orange tint.
8 30	= 27	8·4	...	8·4	
8 50	27 + 2 = 34	8·6 8·6	...	8·6	
9 5	34 + 3	8·9	8·9	8·9	Aperture of tel. reduced to 3 in.·7.
9 10	22 − 2 34 + 6	9·2 9·2	...	9·2	
9 25	22 − 1	9·3	...	9·3	
9 32	= 22	9·4	9·4	9·4	
9 40	= 22	9·4	9·4	9·4	
10 20	= 22	9·4	...	9·4	Ruddy orange.
12 6	22 − 1	9·3	9·3	9·3	
12 15	= 34	8·6	...	8·6	
12 22	= 27 − 1 = 29	8·3 8·3	...	8·3	
12 30	30 + 2	8·3	8·3	8·3	
12 37	30 + 1	8·2	8·2	8·2	(Mag. power 70.)
12 43	= 30	8·1	8·1	8·1	White or very pale yellow ?
12 55	30 − 1	8·0	...	8·0	White.
13 0	30 − 2	7·9	...	7·9	White.
1887 February 25 (Friday). Minimum ($9^{m}·4$) at 8^{h} $34^{m}·5$ G.M.T. = 8^{h} $43^{m}·8$ Paris M.T.					
6 30	30 + 2; 27 − 1	8·3 8·3	...	8·3	Slight orange tint (daylight).
6 40	= 27	8·4	8·4	8·4	Decidedly ruddy (38).
6 46	= 34; 27 + 2	8·6 8·6	...	8·6	
6 57	... ...	...	8·8	8·8	Very ruddy.
7 4	34 + 3; 22 − 5	8·9 8·9	8·9	8·9	
7 9	34 + 6	9·2	9·2	9·2	
7 12	34 + 7; 22 − 1	9·3 9·3	9·3	9·3	
7 15	22 − 1	...	...	9·3	
7 20	22 − 0·5	...	...	9·35	Ruddy; certainly hardly so faint as 22.
7 24	= 22	...	...	9·4	
7 30	= 22	...	9·4	9·4	Ruddy.
7 37	22 − 0 − ?...	...	...	9·35?	Two comites well seen; power 191.
7 40	= 22	...	...	9·4	Power 70.
8 50	= 22	9·4	9·4	9·4	
9 20	= 22	9·4	...	9·4	Decidedly orange ruddy.
9 30	= 22	9·4	9·4	9·4	
9 35	= 22	9·4	9·4	9·4	

U Cephei—continued.

Time of Obs. G.M.T.	Light Estimates.	Deduced Mags.	Mag. gauged.	Mean Mag.	Remarks.
1887 FEBRUARY 25 (Friday)—*continued.*					
h m					
9 40	=22	9·4	9·4	9·4	
9 45	=22	9·4	9·4	9·4	
9 50	=22	9·4	9·4	9·4	
9 55	22−1	9·3	...	9·3	Beginning to brighten up?
10 0	22−2	9·2	9·2	9·2	
10 3	... ...	...	9·0	9·0	
10 9	=34	8·6	...	8·6	Hardly so ruddy as 34?
10 15	=27	8·4	...	8·4	White or pale yellow.
10 20	30+1·5; 27−1·5 ...	8·25 8·25	...	8·25	
10 55	30−1	8·0	8·0	8·0	White, perhaps barely so white as 30.
1889 FEBRUARY 2 (Saturday).					
6 36	34+0+1...	8·4 8·5	...	...	U orange ruddy, interrupted by clouds; doubtful observation; a strong N.W. wind blowing.
6 45	34+6; 22−4	9·0 9·0	...	...	Caught between clouds.
6 50	... ...	...	9·0	...	
7 0	22−2	9·2	...	...	
7 7	22−2	9·2	...	...	
7 10	22−1	9·3	...	...	
8 0	=22	9·4	...	...	18 orange tint=30.
9 7	22−1	9·3	9·3	...	
9 14	22−1	9·3	9·3	...	Decidedly ruddy.
10 15	... ...	...	...	...	Hopelessly cloudy for the last half-hour or more. A fall of snow later.

Mr. Knott's diagram, epoch 1860.

T and U Tauri.



Mr. Baxendell's magnitudes of Comparison Stars :

$a =$ 8·1	$e =$ 10·5	$k =$ 12·3	$o =$ 12·3
$b =$ 9·0 var	$f =$ 10·5	$l =$ 12·7	$p =$ 9·5
$c =$ 9·8	$g =$ 10·9 var	$m =$ 13·3	$q =$ 11·5
$d =$ 10·2	$h =$ 11·5	$n =$ 13·6	$x =$ 11·6

y on the diagram indicates the place of Hind's Variable Nebula.

z on the diagram is the approximate place of a new Nebula discovered by OΣ (*Astron. Nachr.*, No. 1689).

U Tauri.

This star is not given in Chandler's "Third Catalogue," and its variability is extremely doubtful, as the following observations tend to show :—

U Tauri.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863. Nov. 30	h m	60	$=b$	9·0 ±	9·0 ±	b is variable according to Baxendell.
1864. Sept. 27·4		60	$b+2$... ...	9·2	9·2	
Oct. 7·4		60	$b+0+1$ ...	9·0 9·1	9·05	Could not see Hind's nebula.
Nov. 5·3		60	$b+3+4;\ c-5$	9·3 9·4 9·3	9·3	
1865. Aug. 24·6		60	... ...	9·3 ±	9·3 ±	
Nov. 15·5		...	$\frac{1}{2}(b+c)$ nearer to b?	9·3 ±	9·3 ±	
1866. Jan. 6·5		...	$b+4;\ c-4$...	9·4 9·4	9·4	
Mar. 12·3		70	... ...	9·3 ± est.	9·3 ±	Clear. Bad definition.
16·3		70	$c-5$? ...	9·3?	9·3?	
Aug. 16·5		70	$b+2+3$ ...	9·2 9·3	9·5	
Sept. 15·4		70	$=c$?? ...	9·8??	9·8??	
17·5		...	$b+4;\ c-4$...	9·4 9·4	9·4	Bluish white.
Oct. 8·4		70	$b+4;\ c-4$...	9·4 9·4	9·4	
22·6		70 173	... ...	9·4 est.	9·4 est.	Moon troublesome.
Nov. 3·3		...	$b+3;\ c-5$...	9·3 9·3	9·3	
27·4		70	... ...	9·0 ±	9·0 ±	
Dec. 7·3		89?	$\frac{1}{2}(b+c)$ nearer to b	9·3	9·3	Bad definition.
1867. Jan. 2·4		70	$b+4;\ c-4$...	9·4 9·4	9·4	$b=9·0$.
4·4		70	$b+4;\ c-4$...	9·4 9·4	9·4	Cold, tolerably clear, snow on ground. Thermometer in observatory 23°.
Feb. 6	11 ±	70	$b+4;\ c-4$...	9·4 9·4	9·4	
14	8 ±	70	A few tenths $>c$	9·4 ±	9·4 ±	Moonlight. Bad definition.
Oct. 19	10 50	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Slightly ruddy.
Nov. 2	9 20	70	$\frac{1}{2}(b+c)$ ...	9·4 ±	9·4	
13	10 30	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	
23	8 45	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	
Dec. 4	10 15	70 89	$=b$	9·0	9·0	Examining *U Tauri* with power 89 I was dissatisfied with its definition. On applying a power of 191 I found it to consist of two equal stars at an estimated distance of 1″·5 nearly in the meridian. P = 10° or 15°. Haze troublesome. I was preparing to measure them in P and D, but clouds came up and all hope of doing so was taken away.
5	11 30	191	... ...	...	...	Just able to confirm from obs. between clouds the duplicity of *U Tauri*. The components very nearly equal. Is the s.p. star rather the larger? P = 20° or 30°. Observed also by Mrs. Knott, who thought them "*as nearly equal as can be.*"

U Tauri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867. Dec. 7	h m 8 ±	70 191	$b+6$; $c-1-2$?	9·6 9·7 9·6	9·6	$b=x$. With 191 *U* neatly double. The components equal or nearly so. *Perhaps* the s.p. star slightly the larger.
12	7 40 ±	70 191	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Definition too bad to see more than a blotty elongated image.
18	8 25	...	... ...	9·3 ±	9·3 ±	Double, close. The components equal or very nearly so.
22	9 0	191	$\frac{1}{2}(b+c)$ combined mag.	9·4	9·4	Components very nearly equal. Perhaps the s.p. star rather the larger.
27	11 10	70 191	... ...	9·4	9·4	Definition blotchy and stars not seen clearly severed.
1868. Jan. 20	11 0	60 191	... ...	9·4	9·4	The components equal, but definition bad.
Feb. 6	7 ±	70 89	... ...	9·5 ±	9·5 ±	The two components as one star.
11	11 10	70	$b+3$; $c-5$...	9·3	9·3	Definition bad and stars 4^h past merid. The image too blotty with 191 to enable me clearly to see the two components.
Nov. 5	10 25	70	... ...	...	9·3 ±	As one star. The components close and nearly, if not quite, equal. Not well defined. The s.p. star *perhaps* (??) the larger (191, 258).
Dec. 23	8 0	70 89	$b+5$; $c-3$ (as one star)	9·5 9·5	9·5	A close double. D not more than *1″·5 I should think. I think that the s.p. star is rather the larger of the two (191, 258).
1869. Jan. 5	8 45	70 191	$b+4$; $c-4$...	9·4 9·4	9·4	A pretty double star nearly equal. The s.p. star perhaps slightly the larger. Distance estimated at about *1″·5.
19	12 0	70	... ...	9·4 ±	9·4 ±	
Feb. 4	9 15	70	... ...	...	9·3 est.	
27	8 50	70	$b+2$; $c-6$...	9·2 9·2	9·2	The two components seem to me to be nearly or quite equal in magnitude. Distance estimated about $1\frac{1}{2}''$ (191 power).
Nov. 6	9 0	89	$\frac{1}{2}(b+c)$ ...	9·4	9·4	
30	8 10	89 191	... ...	9·4 est.	9·4 est.	Confused, and not very clear. Cold wind from N.N.W. No nebula seen.
Dec. 24	7 15	70 89	... ...	...	9·2 est.	Definition too bad to bear higher mag. power. Only seen as one star.
1871. Mar. 18	8 15	70	... ...	...	9·3 ±	Both components as one star.
1872. Oct. 7	11 50	70?	Double — unchanged?	...	...	Clouds very troublesome and observation worthless.
9	11 0	191	$\frac{1}{2}(b+c)$ as one star	9·4	9·4	Double. The s.p. star the brighter.
1876. Dec. 22	9 5	89 191	... ...	9·5	9·5	Two equal stars. As one star about $9\frac{1}{2}$ mag. I do not see Hind's nebula.

* It is probable that these distance estimates are considerably too small, owing, perhaps, to the comparative faintness of the star.

U Tauri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877. Jan. 17	h m 11 30	89 70 191	... ...	9·0 as one star	9·0	As one star 9·0 mag. ±. The components nearly equal. The s.p. star perhaps rather the larger.
20	7 15	115	As one star $9\frac{1}{4}$ mag.	9·3	9·3	The s.p. component slightly but decidedly the brighter.
30	9 5	70	... ...	9·3	9·3	As one star $9\frac{1}{4}$ est.
Feb. 16	9 0	70	$c-5$ ...	9·3	9·3	As one star $9\frac{1}{4}$ mag. est. With 115 components nearly equal. S.p. star slightly the brighter of the two.
Sept. 28	12 15	70	$b+4$; $c-4$ (as one star)	9·4 9·4	9·4	$P=20°\pm$. The s.p. star the brighter rather, but decidedly. 115, 191.
Oct. 5	12 15	70	$b+2$ ...	9·2	9·2	As one star.
9	12 10	70	$b+2$ ...	9·2	9·2	As one star.
Nov. 1	11 15	70 115 191	$b+2$; $c-6$...	9·2 9·2	9·2	As one star. The components equal or nearly so. The s.p. star perhaps rather the larger, and ruddy?
14	9 5	70 115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star. The s.p. of the two components slightly but decidedly the brighter of the two.
Dec. 6	11 30	70	$b+4$; $c-4$...	9·4 9·4	9·4	As one star. With 115 the components pretty nearly equal.
10	10 50	70 115	$b+3$; $c-5$...	9·3 9·3	9·3	As one star. The components with 115 nearly equal. The s.p. star rather the brighter.
1878. Jan. 30	8 20	70	$b+4$; $c-4$...	9·4 9·4	9·4	As one star. With 115 I think the components very nearly equal in magnitude, but definition very poor.
Mar. 25	8 30	70	$b+3$; $c-5$...	9·3 9·3	9·3	As one star.
Nov. 2	11 5	70	$b+3$; $c-5$...	9·3 9·3	9·3	As one star. Hazy.
1879. Jan. 15	11 0	70	$b+2$; $c-6$?	9·2 9·2	9·2	As one star. With 115 components about equal in mag. I do not see any trace of Hind's nebula.
Mar. 13	7 45	70	$b+2$; $c-6$...	9·2 9·2	9·2	As one star.
Oct. 11	10 30	70 115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star.
15	11 20	70 115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star. Components slightly unequal, n.p. star rather the larger [sic: qu. n.f. or s.p.?].
Nov. 5	8 25	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star.
13	8 35	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Clear, but bad definition.
Dec. 2	10 55	70 115	$b+3$; $c-5$...	9·3 9·3	9·3	As one star. With 115 neatly seen double. The n.f. star rather the brighter of the two.
16	9 0	70	As one star $b+3$; $c-5$	9·3 9·3	9·3	The components equal. 89, 115, 191.
29	10 45	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Very bad definition. With 191 as well as I can make out components equal. Bright moonlight.

U Tauri—continued.

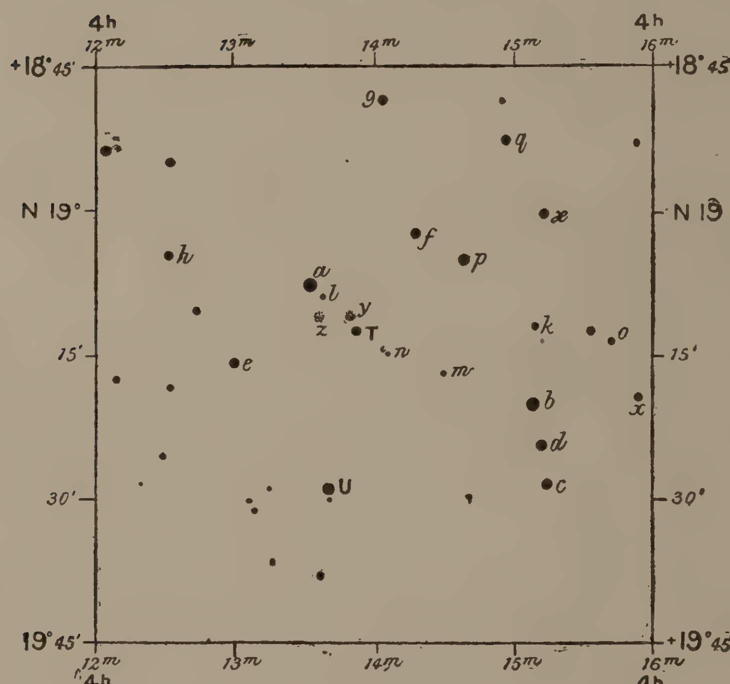
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1880. Oct. 11	h m 10 25	70 115	$b+4$; $c-4$...	9·4 9·4	9·4	As one star. Wind N.E. Bad definition.
Dec. 24	8 15	70	$b+3$; $c-5$...	9·3 9·3	9·3	As one star. Components as viewed with 115 nearly equal, s.p. slightly larger of two ? ? *n* seen, *m* not seen.
1881. Nov. 29	9 0	70 191	$b+2$... ...	9·2	9·2	The components equal. 9·2 ±. Moonlight, sky hazy.
Dec. 13	8 5	70 115	As one star $b+3$; $c-5$	9·3 9·3	9·3	With 115, 191 components equal? Definition very poor.
1882. Dec. 4	8 15	70	As one star, gauged 9·5	9·5	9·5	With 110 the components sensibly equal. The s.p. star perhaps slightly the larger.
1883. Jan. 27	7 40	110	$\frac{1}{2}(b+c)$ as one star	9·4	9·4	Components about equal.
Apr. 2	9 0	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	
Nov. 17	8 30	70 115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Vision very confused, and stars not separated.
26	11 15	115	... ...	...	9·3	Components equal, $n > m$.
1884. Oct. 24	11 15	70 191	$b+4$; $c-4$...	9·4 9·4	9·4	The components of *U* equal. Perhaps n.f. star slightly the brighter. *n* seen, I do not see *m*.
1885. Jan. 22	8 10	70	$b+4$; $c-4$...	9·4 9·4	9·4	As one star.
Nov. 17	8 30	70 115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	The s.p. star rather the brighter.
Dec. 15	9 0	70 115	$\frac{1}{2}(b+c)$ as one star	9·4	9·4	The components equal ?
1886. Nov. 2	10 30	70 115	$b+3$; $c-5$...	9·3 9·3	9·3	As one star. Components about equal.
Dec. 1	8 40	70 115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	The s.p. star perhaps slightly the brighter.
18	8 35	...	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Components equal ?
1887. Feb. 8	8 0	70	$b+4$; $c-4$...	9·4 9·4	9·4	9·3·4 ± est. as one star. With 115, 191 the components equal ? Poor definition (bright moonlight).
Mar. 16	8 0	70 110 200	$b+2$? $+3$?	9·2 ? 9·3 ?	9·25 ?	Rather brighter than sometimes ? Bad definition, so that components not *well* seen. Seemingly about equal ?
1888. Nov. 6	9 0	...	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star.
Dec. 6	8 50	70 115 191	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star. Very bad definition. The components not separated.
12	8 0	70 115 191	As one star $b+4$; $c-4$	9·4	9·4	The components equal. The s.p. star slightly ruddy. Definition not good. As one star, gauged 9·4.
1889. Jan. 29	8 40	191	$\frac{1}{2}(b+c)$ as one star	9·4	9·4	The two components equal. Bad definition.
Oct. 31	10 25	70	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star. With 115 components equal.

U Tauri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889. Nov. 25	h m 9 0	70 191	As one star $\frac{1}{2}(b+c)$	9·4	9·4	The components equal or nearly so. Perhaps the s. star slightly brighter.
1890. Nov. 1	11 40	70 115	As one star $b+3$; $c-5$	9·3 9·3	9·3	Components nearly equal. S.p. rather brighter of the two?
Dec. 9	8 40	115 191	As one star $\frac{1}{2}(b+c)$	9·4	9·4	Components equal. Perhaps the s.p. star slightly the larger. No decided colour.
10	8 5	115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	As one star, gauged 9·4 9·5. Components nearly equal, s.p. star slightly the larger.
12	8 55	115 200 70	As one star $\frac{1}{2}(b+c)$	9·4	9·4	Components nearly equal. S.p. star slightly the larger. I cannot assure myself of any colour.
13	8 45	115	As one star ...	9·4	9·4	Stars equal. White?
1891. Jan. 1	10 3	70 115 191	As one star $\frac{1}{2}(b+c)$	9·4	9·4	The components sensibly equal.

Mr. Knott's diagram, epoch 1860.

T and U Tauri.



Mr. Baxendell's magnitudes of Comparison Stars :

$a =$ 8·1	$e =$ 10·5	$k =$ 12·3	$o =$ 12·3
$b =$ 9·0 var	$f =$ 10·5	$l =$ 12·7	$p =$ 9·5
$c =$ 9·8	$g =$ 10·9 var	$m =$ 13·3	$q =$ 11·5
$d =$ 10·2	$h =$ 11·5	$n =$ 13·6	$æ =$ 11·6

y on the diagram indicates the place of Hind's Variable Nebula.

z on the diagram is the approximate place of a new Nebula discovered by OΣ (*Astron. Nachr.*, No. 1689).

T Tauri.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 1537, *T Tauri*, R.A. for 1900·0 = $4^h\ 16^m\ 10^s$, Decl. = + 19° 17′·8.

Annual Variation = + $3^s{\cdot}49$ and + 0′·15.

R.A. for 1855·0 = $4^h\ 13^m\ 33^s$, Decl. = + 19° 11′·3.

Redness = 0. Max. magnit. = 9·2 — 11·5. Min. = 12·8 — < 13·5. Irregular.

Discovered by Hind, 1852; confirmed by Auwers and Chacornac. Preceding the variable $1^s{\cdot}8$, south 0′·4, is a nebula, discovered by Hind, 1852, supposed by D'Arrest to be itself variable; and later observations, by Lassell, Struve, Burnham, and Barnard, seem to render this probable.

[See also paper by Barnard, *Monthly Notices*, Vol. LV. page 8.]

T Tauri.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863. Nov. 30	h m	60	$=h$	11·5	11·5	
1864. Sept. 27·4		60	$e+1$; $f+1$ ...	10·6 10·6	10·6	Comp. star b, 9·0 mag. (Var. Baxendell.)
Oct. 7·4		60	$=e$; $=f$ ...	10·5 10·5	10·5	Could not see Hind's variable nebula.
Nov. 5·3		60	$=e$; $=f$ ...	10·5 10·5	10·5	Hind's nebula invisible. Not very clear.
1865. Aug. 24·6		60	$=f$	10·5	10·5	No signs of Hind's nebula.
Nov. 15·5		60	$f+5$; $h-5$...	11·0 11·0	11·0	No signs of Hind's nebula. l est. 12·8; $b=x+0+1$; $x=8·9$ 9·0. Place of x, 1860·0, $\alpha=4^h\ 15^m\ 55^s$; $\delta=+19°\ 19'$. Place of b, $\alpha=4^h\ 15^m\ 10^s$; $\delta=+19°\ 19'$.
1866. Jan. 6·5		70	$=h$? ...	11·5?	11·5?	Hind's variable nebula not visible. Clear.
Mar. 12·3		70	... ...	13·3	13·3	No trace of Hind's nebula. Clear. Definition bad.
16·3		70 102	$l+5$; $=n$ ...	13·2 13·3	13·25	Qu. Is $n>m$ and of 13·3 mag.?
Aug. 16·5		70	... ...	13±	13±	$6\frac{1}{4}^h$ from meridian. Did not see Hind's nebula.
Sept. 15·4		70 89 173	... ...	13±	13±	Obs. made at $10^h\ 20^m$. The field $6\frac{1}{4}^h$ from meridian. T a glimpse object, less than l (12·7), very considerably less than k (12·3). I doubt whether it can be above 13 mag. Sky clear at first, but clouds came up and put an end to observation. Observed in consequence of a letter from Mr. Baxendell, who says that, according to his elements, the var. ought to be approaching another maximum.
17·5		89	$k+5+6$; $l+2$; m (?) -4	12·8 12·9 12·9 12·9	12·9	$12^h\ 30^m$. I do not see n.
24·6		70 89 156 191	$<l$	Under 12·7	Under 12·7	Not easily seen in bright moonlight, but I think T is decidedly less than l. Not well seen, and obs. worthless. $14^h\ 20^m$.
Oct. 8·4		173	Not $>l$ ...	$12\frac{3}{4}$ 13?	12·9	Only glimpsed; 5^h from meridian, definition bad and sky rather hazy. Neither T nor l well seen.
22·6		173	$l-2$? ...	12·5?	12·5?	Moon troublesome.
Nov. 3·4		70 173	$<l$ ...	<12·7	<12·7	A glimpse object.
6·5		70 173 191	Not $>l$ ...	Not > 12·7	Not > 12·7	Glimpsed. Hazy.
13·4		70 191	... ...	13± ?	13±?	Less than l.
27·4		89	$l+3$? ...	13·0?	13·0?	Less than l. I see a faint star about $13\frac{1}{2}$ mag., which I take for n. I do not see m.
Dec. 7·3		89	$l+2+3$? ...	...	...	
31·4		70 89 191	$h+5$; $k-3$...	12·0 12·0	12·0	12·0 est. 6-in. aperture in telescope. No trace of Hind's nebula.
1867. Jan. 2·4		70	$k-3$ ...	12·0	12·0	12·0± est. n (?) seen. 13·2± ?

T Tauri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
Jan. 4·3		70	$h+3$; $k-5$	11·8 11·8	11·8	*m* and *n* both seen and of about mag. assigned by Mr. Baxendell. I do not see Hind's nebula. Cold and tolerably clear. Thermometer in observatory, 23°. Snow on ground.
8·3		70 89	... ...	12 ± est.	12 ± est.	Among clouds.
11·3		60 70	$g+7$; $h+1+2$	11·6 11·6 11·7	11·6	Certainly not greater than *h*. *a* hidden by bar.
14	10 0 ±	70 89	A few tenths $<h$?	$11\frac{1}{4}$?	$11\frac{1}{4}$?	Moonlight and haze. Snow in air.
Feb. 6	11 0	70	$f+8$; $h-3$...	11·3 11·2	11·25	
14	8 0 ±	70	$f+7$; $h-3$...	11·2 11·2	11·2	Moonlight. Bad definition.
Oct. 19	10 50	70	$=e$	10·5	10·5	I do not see Hind's nebula; but moon rising.
Nov. 2	9 15	89	$e+1$; $f+1$ ...	10·6 10·6	10·6	I do not see Hind's neb. 4ʰ from merid.
13	10 30	70	$d+3$; $f+0+1$	10·5 10·5 10·6	10·5	Moon bright and near (nearly full). Flying haze.
23	9 0	70	$f+0+1$ ...	10·5 10·6	10·55	I do not see Hind's nebula; but sky slightly hazy.
Dec. 4	10 15	60 70	$e+5$; $h-5$...	11·0 11·0	11·0	*g* surely brighter than 10·9 mag. I had a vague suspicion of a slight nebulosity closely s.p. *T Tauri* (Hind's nebula). I have no confidence, however, in the observation.
7	8 50	70	Some few tenths $<e$ and f	11 ±	11 ±	Moonlight troublesome.
12	7 30	70	... ...	11 ±	11 ±	
18	8 20	70	... ...	11·0 ±	11·0 ±	
22	9 0	70	... ...	11·0 ±	11·0 ±	
27	11 20	70	... ...	11·0	11·0	
1868.						
Jan. 20	11 0	60	$e+3$; $f+3$; $h-7$	10·8 10·8 10·8	10·8	Query. Rather brighter again?
Feb. 6	7 0 ±	70 89	$f+2$; $g-2$...	10·7 10·7	10·7	
11	11 15	70	... ...	11·0	11·0	
Oct. 7	9 15	70	$f+2$? ...	10·7 ±	10·7 ±	Slightly less than *e* and *f*; 6ʰ from merid. Too far from merid. and def. too poor to enable me to make anything of *U Tauri*. No signs of nebulæ.
Nov. 5	10 15	70	$=e, f$ ...	10·5 10·5	10·5	Slightly ruddy? Field illuminated by rising moon; ∴ nebulæ impossible.
Dec. 23	7 50	70 89	$e+3$; $f+3$; $h-7$	10·8 10·8 10·8	10·8	
1869.						
Jan. 5	8 40	70	$e+6$; $h-4$...	11·1 11·1	11·1	Clear sky. I do not see Hind's or OΣ's nebula.
19	11 50	70	$e+6$; $h-4$...	11·1 11·1	11·1	With power 89 I searched for Hind's and OΣ's nebulæ, but without success.
Feb. 4	9 15	70	$f+5$; $h-5$	11·0 11·0	11·0	$g=10^m{\cdot}7$ or $10^m{\cdot}9$?
27	8 45	70	$f+8$; $h-2$...	11·3 11·3	11·3	

T Tauri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869.	h m					
Nov. 6	9 0	89	... ...	...	13·3 est.	Some tenths < *l*.
30	8 10	89 191	... ...	...	13·3 est.	Some tenths < *l*.
Dec. 24	7 15	70 89	... ...	...	13·5 est.	
1871. Mar. 18	8 15	70 102	... ...	...	$13\frac{1}{2}$ est.	I do not see either Hind's or OΣ's nebula, but haze about. I see either *n* or *m*, but not both. I believe it to be *n*. About $13\frac{1}{2}$ mag. + ?
1872. Jan. 8	8 40	115	= *n*	13·6	13·6	I do not see Hind's nebula. *m* (if seen) considerably fainter than *n*. The two components of *U Tauri* about equal.
Oct. 7	11 50	70 (?)	Glimpsed ? ...	...	...	If seen at all (which is doubtful), very much less than *l*.
9	11 0	191	... ...	$13\frac{3}{4}$ est.	13·75 est.	A glimpse object.
1876. Dec. 22	9 0	70	*c*+2; *d*−2; *f*−5	10·0 10·0 10·0	10·0	Ruddy ?
1877. Jan. 17	11 30	70 89	*b*+8; =*c* ...	9·8 9·8	9·8	Slightly orange tint ? I do not see either Hind's or OΣ's nebula; rather hazy.
20	7 15	70 115	=*c*; *d*−4 ...	9·8 9·8	9·8	Ruddy ? Moonlight.
30	9 5	70	=*c*	9·8	9·8	Decidedly ruddy.
Feb. 16	9 0	70	*c*−0−1 ...	9·8 9·7	9·75	Decidedly ruddy. $9\frac{3}{4}^{m}$ full est. ?
Apr. 7	8 45	70 115	... ...	$10\frac{3}{4}$?	10·75 est.	Less than either *e* or *f*. Obs. difficult and interrupted, and finally closed by clouds. Star $5\frac{1}{2}^{h}$ past meridian.
Sept. 28	12 15	70	*c*+2; *d*−2...	10·0 10·0	10·0	10 ± est. Ruddy ? Moonlight. Moon rather near.
Oct. 4	11 50	70 115	=*c*; *c*− ? ...	9·8 (9·8−?)	9·8	Ruddy. I do not see either Hind's or OΣ's nebulæ; but qu. is there a very minute star near the place of Hind's nebula ? (? ? ?)
5	12 15	70	*b*+4; *c*−4...	9·4 9·4	9·4	Slightly ruddy ? I fail to see either Hind's or OΣ's nebulæ, nor do I suspect a small star to-night near the place of the former; *l* a conspicuous object.
9	12 10	115	$\frac{1}{2}(b+c)$ ...	9·4	9·4	Ruddy.
27	10 40	70	=*c*	9·8	9·8	Slightly ruddy. Moonlight.
Nov. 1	11 10	70 115	=*c*	9·8	9·8	I do not see Hind's or OΣ's nebulæ. (70, 115, 191 mag. power.)
14	9 5	70 115	=*c*; *c*−1?...	9·8 9·7	9·75	Ruddy lilac.
Dec. 6	11 30	70	*b*+6; *c*−2...	9·6 9·6	9·6	Slightly ruddy. I do not see either Hind's or OΣ's nebulæ. *T* not quite so bright as *U*.
10	10 50	70 115 191	*b*+6; *c*−2...	9·6 9·6	9·6	Ruddy lilac. I fail to see any trace of Hind's nebula, but at times almost fancy that I glimpse a minute star near the place.

T Tauri—continued.

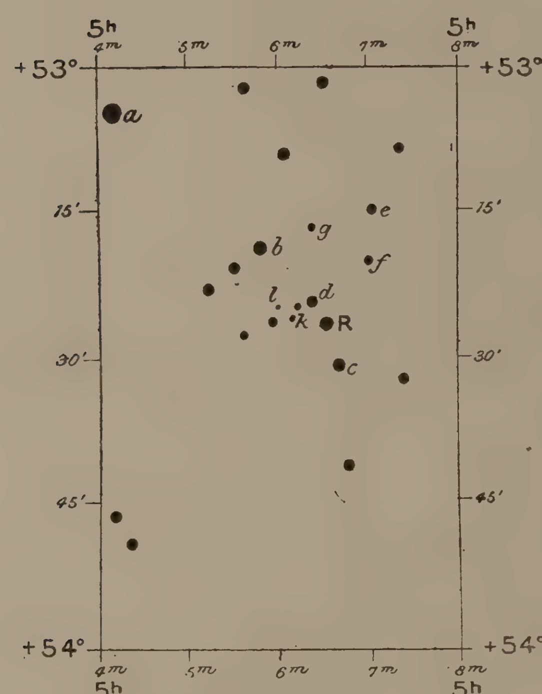
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1878. Jan. 30	h m 8 15	70	$b+4$; $c-4$...	9·4 9·4	9·4	Ruddy lilac. Equal to *U Tauri* seen as one star.
Mar. 25	8 30	70	$b+6$; $c-2$...	9·5 9·5	9·5	Slightly ruddy lilac.
Nov. 2	11 5	115	$c+2$; $d-2$...	10·0 10·0	10·0	Pale lilac. 10 mag. est.
1879. Jan. 15	11 0	70	$=c$? $c-1$?	9·7 9·8	9·75	Lilac or ruddy lilac.
Mar. 13	7 45	70 115	$b+5$; $c-3$...	9·5 9·5	9·5	Lilac tint? Bad definition but clear. I do not see anything in place of Hind's nebula. l pretty well seen. 115 mag. power.
Oct. 11	10 30	70 115	$=c$	9·8	9·8	Bluish white. I do not see Hind's nebula. l and n visible, not m?
15	11 20	70 115	$=c$	9·8	9·8	Lilac tint? Hind's nebula not seen.
Nov. 5	8 25	70	$=c$	9·8	9·8	
13	8 35	70	$=c$	9·8	9·8	Clear but bad definition.
Dec. 2	10 55	70 115	$=c$; $c-1$ ...	9·8 9·7	9·75	Lilac tint.
16	8 50	70	$=c$	9·8	9·8	Lilac; n some tenths $>m$, which is very faint. Say $n=13·3$, $m=13·7$. No signs of Hind's or OΣ's nebulæ.
29	10 45	70	$=c$	9·8	9·8	Ruddy lilac.
1880. Oct. 11	10 20	70 115	$b+5$; $c-3$...	9·5 9·5	9·5	Lilac. I do not see Hind's nebula. l well seen. Neither n or m seen. 4^h from meridian.
Dec. 24	8 10	70	$c-0-2$ ...	9·8 9·6	9·7	Lilac tint. No signs of Hind's nebula, but not quite clear.
1881. Nov. 29	9 0	70	$c+2$; $d-2$?	10·0 10·0?	10·0?	About 10·0. Lilac, ruddy?
Dec. 8	8 50	70 115	$c+2$; $d-2$	10·0 10·0	10·0	About 10 mag. Cloudy.
13	8 5	115 70	$=c$? ...	9·8	9·8	Lilac tint. Hind's nebula not seen. n glimpsed. m not seen.
1882. Dec. 4	8 15	70	$d+2$; $f-1$	10·4 10·4	10·4	
1883. Jan. 27	7 40	110	$=h$	11·5	11·5	No signs of Hind's nebula. m and n seen.
Apr. 2	9 0	70	$=e$; $=f$ ...	10·5 10·5	10·5	
Nov. 17	8 30	70	$e+2$; $f+2$...	10·7 10·7	10·7	Moonlight.
26	11 15	115	$=h$	11·5	11·5	No signs of Hind's nebula.
1884. Oct. 24	11 5	70 115	$g+6$; $=h$; $k-8$	11·5 11·5 11·5	11·5	No signs of Hind's nebula. A clear sky.
1885 Jan. 22	8 20	115	... ...	...	11·5 ±	Very difficult observation. A hazy and most variable sky. All observations most difficult and unsatisfactory.
Nov. 17	8 30	115	$h+3$; $k-5$	11·8 11·8	11·8	12 mag. ± est.
Dec. 15	9 0	115	$g+4$; $h-2$	11·3 11·3	11·3	

T Tauri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1886.	h m					
Nov. 2	10 30	115	$h+5$; $k-3$	12·0 12·0	12·0	About 12 mag.
Dec. 1	8 40	115	$g+5$; $h-1$	11·4 11·4	11·4	
18	8 30	...	$=h$	11·5	11·5	$11\frac{1}{2}$ ± est. No nebulosity seen.
1887.						
Feb. 8	7 55	115	$h+4$; $k-4$	11·9 11·9	11·9	Bright moonlight.
Mar. 16	8 0	70 110 200	$k-3$ ...	12·0	12·0	
1888.						
Nov. 6	9 0	115	Not seen ...	Under 13	< 13	*l* well seen.
Dec. 6	8 50	115	Not seen ...	Under 13	< 13	*l* seen at times.
12	8 5	115	Not seen ...	Under 13	< 13	*l* well seen. Haze and bright moonlight.
1889.						
Jan. 29	8 45	115	Not seen ...	Under 12·7	< 12·7	*l* seen. Hazy sky.
Oct. 31	10 22	115	Not seen ...	Under 13·5	< 13·5	*l* well seen.
Nov. 25	8 47	115	$=n$	13·6	13·6	Nearly a mag. less than *l*. No nebula seen near it.
1890.						
Nov. 1	11 47	115	Not seen ...	Under 13	< 13	*l* well seen. *m* and *n* not seen.
Dec. 9	8 45	115	$l+7$; $n-2$...	13·4 13·4	13·4	
13	8 40	115	$n-1$ ...	13·5	13·5	13·5 est. I do not see *m*.
1891.						
Jan. 1	10 12	115	$n-2$ ...	13·4	13·4	*n* well seen. *m* seen also; fainter than *n*. About 13·8?

Mr. KNOTT'S Diagram, Epoch 1866 ?

R Aurigæ.



Approximate magnitudes of Comparison Stars :

$a = 6{\cdot}3$	$d = 9{\cdot}5$	$g = 10{\cdot}9$
$b = 8{\cdot}2$	$e = 9{\cdot}9$	$k = 12{\cdot}4$? ?
$c = 9{\cdot}0$	$f = 10{\cdot}6$	$l = 13{\cdot}5$

R Aurigæ.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 1855 *R Aurigæ*, R.A. for 1900·0 = $5^h\ 9^m\ 13^s$, Decl = $+53°\ 28'·4$.
Annual Variation $+4^s·83$ and $+0'·07$.
R.A. for 1855·0 = $5^h\ 5^m\ 36^s$, Decl. = $+53°\ 25'·0$.
Redness = 6·5. Max. mag. = 6·5 − 7·8. Min. = 12·5 − 12·7.
M − m = 248^d.
Maximum, 1862 November 17 = 2401462^d (Julian).
Period = $460^d·2$.
(From 17 observations of max. and 6 of min., including observations in 1862–74, and 79–94.)

Discovered at Bonn, 1862. Schönfeld notes and Chandler's observations confirm the unusual phenomenon of a "standstill" during increase at about 9^m, from 2 to 4 months before maximum 9^m pr. 5^s, $0'·6$ S.

R Aurigæ.

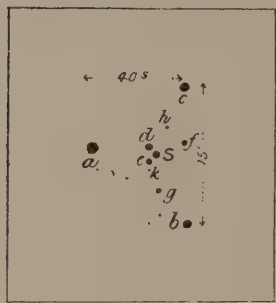
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865. Aug. 22·4	h m	...	= or rather < *d*, < *c*	$9\frac{1}{2}$ ±	9·5 ±	
25·6		60	= *d*	9·5	9·5	*R* red. *d* bluish?
30·4		...	*d* + 0 + 1 . .	9·5 9·6	9·55	
Sept. 7·4		60	*d* + 1... ...	9·6	9·6	
18·3		60	*e* + 3·5 ; *f* − 3·5	10·25 10·25	10·25	
Oct. 4·5		70	*g* + 0 − 2 [sic]	10·9 11·1 [sic]	11·0	
20·3		70	$\frac{1}{2}(g+k)$ ...	11·7	11·7	12 ± est.
Nov. 3·4		70	= *k*	12·4	12·4	Gauged photometrically 12·3. Moon and haze troublesome.
13·3		70	= *k*	12·4	12·4	
15·3		70	*k* + 0 + 1 ...	12·4 12·5	12·45	
29·3		191	... ...	13·0 13·3 est.	13·15 est.	
Dec. 14·3		70	... ...	13·3 est.	13·3 est.	
1866. Jan. 8·4		191	A glimpse object	13·7 ±	13·7 ±	
Feb. 3·4		...	... ...	13·6	13·6	
Mar. 10·4		70	*g* + 2... ...	11·1	11·1	
12·4		70	*g* + 0 + 2 ? ...	10·9 11·1	11·0	Hazy. Observation doubtful.
16·3		70	= *g* ; a few tenths < *f*	10·9	10·9	
April 4·4		70	*f* + 0 + 1 ...	10·6 10·7	10·65	
13·4		70	*d* + 6; $\frac{1}{2}(e+f)$	10·1 10·25	10·2	Fine red.
17·4		70	*d* + 6; $\frac{1}{2}(e+f)$	10·1 10·25	10·2	Gauged mags. of comp. stars.
20·3		70	*d* + 6; *e* + 3; *f* − 5	10·1 10·2 10·1	10·1	
25·3		70	$\frac{1}{2}(e+f)$ ...	10·25	10·25	
May 4·5		70	*e* + 3... ...	10·2	10·2	
16·4		70	*d* + 4 ; = *e* ...	9·9 9·9	9·9	
June 25·5		89	*d* + 4 ? = *e*? ...	9·9 9·9	9·9 ?	
July 9·5		70	*c* + 5 ? = *d* ...	9·5 9·5	9·5	Fine red.
14·5		70	= *d*	9·5	9·5	10^h from meridian and bad definition.
20·5		70 89	= *c* ; > *d* ...	9·0	9·0	9^h from meridian and bad definition. The whole of the evening sky hazy.
Aug. 3·5		70	*b* − 4... ...	7·8	7·8	Fine ruddy. Definition bad.
16·5		70 102	*b* − 5... ...	7·7	7·7	Fine red. Determined mags. of comp. stars by method of limiting apertures.
31·5		70	*b* − 3 − 4 ...	7·9 7·8	7·85	Fine coppery red.

R Aurigæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866. Sept. 14·4	h m	70	$b-4$... ...	7·8	7·8	7·8 gauged. *b* gauged, 8·2. *R* fine coppery red.
Oct. 8·3		70	$b+2$... ...	8·4	8·4	Fine red.
Nov. 3·3		70	$\frac{1}{2}(c+d)$ ...	9·25	9·25	Fine red. Clear colour.
13·4		70	$d-0-1$ ...	9·5 9·4	9·45	Gauged mags. of comparison stars.
20·4		70	$d-1$... ...	9·4	9·4	Very decidedly red. *d* bluish.
27·4		70	$d+3$... ...	9·8	9·8	Red. Fine colour.
Dec. 19·3		70	$f+3;=g$ ...	10·9 10·9	10·9	
1867. Jan. 2·4		70	... ...	11·7 12·0 est.	11·85 est.	Snow on ground. Air still and cold. Thermom. in transit room 22°. Definition very poor, but sky tolerably clear.
11·5		70	... ...	12·0 est.	12·0	
Feb. 6	10 0+	70	$k+3+4$ ...	12·7 12·8	12·75	
23	...	70	... ...	13·0 est.	13·0 est.	
Mar. 2	11 0±	89 191	Glimpsed? ...	Certainly < 13	< 13	
5	8 40	70	... ...	13·5 ±	13·5 ±	Gauged mags. of comparison stars.
April 29	11 0+	89 191	Glimpsed? ...	13·7 ?	13·7 ?	
May 23	11 0+	89	A glimpse object	13 ±	13 ±	10ʰ past meridian.
June 26	13 0	89	... ...	$11\frac{1}{4}$ ± est.	11·25 ±	$9\frac{3}{4}$ʰ from meridian. A clear sky. Wind N.N.E.
1868. Feb. 11	11 30±	70	$c+1$; $d-4$...	9·1 9·1	9·1	*R* fine clear coppery red. *d* bluish.
1872. Jan. 6	11 25	115	$f+1$; $g-2$....	10·7 10·7	10·7	Not very well seen.
1879. Aug. 6	11 17	115	$g+8$; $k-7$...	11·7 11·7	11·7	$11\frac{3}{4}$ est. ±.
Oct. 15	12 0	191	Not seen ...	Under 13	< 13	*k* well seen.
1882. Oct. 24	8 30	70 115	$d+10$; $f-1$; $g-4$	10·5 10·5 10·5	10·5	Ruddy. *b* 8·2, *c* 9·0, *d* 9·5.
1883. Feb. 22	10 30	70	$b+6$; $c-2$...	8·8 8·8	8·8	A bright 9 mag.
Mar. 2	8 55	70	$=c$; $c-1$ ...	9·0 8·9	8·95	Red.

Mr. Knott's Diagram.

S Orionis.



Magnitudes of Comparison Stars :

	Knott.	Baxendell.		Knott.	Baxendell.
$a =$	8·1	8·2	$f =$	11·6	11·7
$b =$	9·9	9·8	$g =$	11·8	12·0
$c =$	9·7	{9·7 / 9·9}	$h =$	12·5	12·7
$d =$	10·7	10·6	$k =$	13·3	13·2
$e =$	11·4	11·5			

(*d*, *g*, and *k* slightly variable ?—Baxendell.)

S Orionis.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 1944 *S Orionis*, R.A. for 1900·0 = $5^h\ 24^m\ 5^s$, Decl. = $-4°\ 46'·4$.
Annual Variation $+2^s·96$ and $+0'·05$.
R.A. for 1855·0 = $5^h\ 21^m\ 51^s$, Decl. = $-4°\ 48'·7$.
Redness = 6·4. Max. mag. = 8·3 – 9·5. Min. 11·0 – 13·0.
M – m = 194^d.
Maximum, 1870 February 1 = 2404095^d (Julian).
Period 413^d.

(From thirteen observations of max. and six of min., including observations in 1863–75, 83–96.)

Discovered by Webb, 1870; confirmed by Schönfeld. Marked irregularities, and secondary phases in light-curve. 10^m about 1′ N; $9^m·5$ pr. $2^s·5$, 0′·4 S.

S Orionis.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1871.	h m					
Jan. 5	8 10	89	= ✶10·5 of Mr. Webb's Diagram [d]	10·7	10·7	Faint; not well seen in haze and moonlight. Ruddy, but colour not very decided.
12	7 25	70	$d-0-1$ ...	10·7 10·6	10·65	Clear. Well seen. Slight ruddy tinge?
Feb. 6	6 35	70	Some 5 tenths $>d$	10·2	10·2	Decidedly ruddy. Bright 10 mag. est.
8	7 30	70 89	$b+3$; $d-7$...	10·2 10·0	10·1	Orange red. A bright 10 mag. est. Adopted provisional mags. for comp. stars. *a* 8·0, *b* 9·5, *c* 9·3, *d* 10·5, *e* 11·2. Gauged *a* 8·1.
18	8 10	70 89	$c+4$; $d-6$?	10·1 10·1	10·1	Orange red? Hazy. Not well seen. I feel a little doubt whether it is quite so bright as on February 8.
23	7 45	70	$=c$	9·7	9·7	Coppery red. Certainly brightening up.
Mar. 1	7 0	70	$a+10$; $c-3$	9·1 9·4	9·25	Rose red. Moonlight. Wind S.E. and filmy clouds about.
3	9 0	70	$a+9$; $c-4$...	9·0 9·3	9·15	Fine red.
7	7 40	70	$a+10$ ...	9·1	9·1	As Mr. Baxendell makes *b* brighter than *c*, contrary to Mr. Webb's and my estimations, I asked Mrs. Knott to say which was brighter to her. She at once said that *b* was slightly but decidedly the brighter, thus confirming Mr. Baxendell's estimate. To my eye *c* is decidedly brighter and slightly ruddy. Gauged *c* 9·5–9·7; *d* 10·5; *e* 11·3; *f* decidedly less than *e*. Moonlight and flying clouds. Wind high.
13	9 10	70	$a+9$; $c-7$ ..	9·0 9·0	9·0	Fine red. In finder (2 in.) *b* certainly $>c$, in large telescope certainly $<c$. *f* nearly $=e$. A minute ✶ 12·13 mag.? in line from var. to *e* about ¾ distance beyond. A very rich field. A rather hasty observation.
18	7 45	70	$a+7$; $b-9$...	8·8 9·0	8 9	Fine red, with orange cast. 8¾ or bright 9 mag. est.
22	8 45	70	$a+7$; $b-9$?	8·8 9·0	8·9	Fine orange red. Obs. a little doubtful. Bad definition. Stars flaring.
24	8 25	70	$\frac{1}{2}(a+b)$ ...	9·0	9·0	Orange red.
Apr. 1	7 45	70	$\frac{1}{2}(a+b)-1$?	8·9	8·9	5 inches aperture. Fine orange red. *c* certainly $>b$. Moonlight. *S* between *a* and *b*, but nearer to *a* slightly?
Oct. 9	12 15	115	Feebly glimpsed?	...	...	Less than *g*.
12	11 55	115	... ...	...	13¼?	*h* and *k* seen. *S* glimpsed at times.
23	11 40	115	Not seen ...	Under 11·75	$<11·75$	*g* seen. *k* not seen. *c* is most decidedly brighter than *b*.
Nov. 18	10 10	191	Glimpsed at times	...	13 est.	Stars rather low and hazy at times.

S Orionis—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1871.	h m					
Dec. 4	9 30	115 191	$g+3$; $h-5$...	12·1 12·0	12·05	12 mag. est. Obs. difficult.
12	11 0	191	... ...	...	11·6 ±	$<e, >g$. Qu. is there more than 0·2 between e and g? f and g nearly equal, f the larger. More than 0·1 between n and k (so Webb).
20	10 50	191	$=e$; $e+1$?...	11·4 11·5	11·45	Is the ruddy tint beginning to show?
1872.						
Jan. 6	9 0	115	$d+2+3$; $e-5$	10·9 11·0 10·9	10·9	Ruddy decidedly.
14	9 0	115 191	$d+2+3$? ...	10·9 11·0	10·95	Ruddy. k 13·0 12·8 est.
Feb. 2	8 5	115	$d-2$... ...	10·5	10·5	Orange red. 10½ est.
8	9 10	70 115	$d-3$; $b+5$...	10·4 10·4	10·4	Fine red.
20	6 40	115	$c+5$; $d-5$...	10·2 10·2	10·2	Ruddy. The star seems brightening up very slowly.
Mar. 4	7 15?	115	2 or 3 tenths $>d$?	10·5 10·4?	10·45?	Orange ruddy. Miserable definition.
6	8 50	89	$d-2-3$? ...	10·5 10·4?	10·45?	Fine red.
Apr. 10	8 40	70	$=b$	9·9	9·9	Stars low. Obs. rather doubtful. Orange coloured. About 10 mag.
13	8 15	70	9·5 est. ...	...	...	Some tenths > either b or c. Orange red. Moonlight. Stars low.
Oct. 22	12 10	191	... ...	13¼ est.	13·25	Rather brighter than k, both glimpse objects [13·1?].
Dec. 4	10 10	191	Not seen ...	Under 13·5	< 13·5	k seen.
1873.						
Jan. 28	8 50	191	... ...	12 est.	12·0	Not so bright as g. k 13½ est.
1876.						
Nov. 17	11 20	70	$a+12$; $c-4$?	9·3 9·3	9·3	About 9¼ or 9½ est. Fine ruddy colour. Obs. much interrupted by clouds.
Dec. 22	10 25	70	$a+10$; $c-7$	9·1 9·0	9·05	Fine red. 9¼ est.
1877.						
Jan. 17	11 50	70	$a+12$; $c-5$?	9·3 9·2	9·25	Fine red. 9¼ 9½ est.
20	9 0	70	... ...	...	...	Fine red. 9·3 9·5 est.
25	10 45	70	... ...	9·2 est.	9·2	Fine red. c 2 > b.
Feb. 16	8 50	70	$=b$? ...	9·9?	9·9?	Fine red. 9·5 est.
Mar. 8	9 0	70	$d-1-2$? ...	10·6 10·5	10·55	Decidedly ruddy.
Oct. 4	12 0	70 115	$=d$	10·7	10·7	Low but clear. c certainly to my eye > b.
9	11 55	70 115	$=d$	10·7	10·7	c certainly > b to my eye.
15	12 20	115	$d-1-2$ ...	10·6 10·5	10·55	Certainly red.
22	12 0	70	$d-3-4$ ...	10·4 10·3	10·35	Decidedly red. c certainly several tenths > b. S intermediate in mag. between d and b, perhaps nearer to b.
27	10 45	70 115	$=d$? ...	10·7	10·7	I think not brighter than d, though perhaps slightly so. A good deal of disturbance in the air. Not a good night for observing.

S Orionis—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1877.	h m					
Nov. 1	11 25	70 115	$d+1$? ...	10·8	10·8	Barely equal to d, I think. c decidedly brighter than b.
3	11 5	70 115	$d+1$ ...	10·8	10·8	d certainly rather the brighter of the two. So Mrs. Knott also. With 70 $b>c$ slightly (Mrs. K.), with 115 so also, or nearly equal. G. K. c certainly $>b$.
14	10 30	115	$d+1$ ...	10·8	10·8	Almost as bright as d. Ruddy orange. c some two tenths brighter than b. So also in finder.
	10 40	70	$=d$	10·7	10·7	Decidedly red. d well seen in finder (2 in. aperture) $\therefore = 10·7$ mag.
16	11 10	70	$=d$	10·7	10·7	Decidedly red.
19	11 40	89	$d-2$ ...	10·5	10·5	Decidedly red.
Dec. 6	11 0	70	$c+2$? $d-7$; $e-14$	9·9 10·0 10·0	10·0	c certainly some two or three tenths $>b$. S red and nearly $=c$. About 10 mag. est.
10	11 5	70	$=c$; $d-10$?	9·7 9·7	9·7	Decidedly red and increasing in mag. As much brighter than d (rather more?) as d is than e.
18	10 20	[89?]	$a+12$; $c-4$? $d-13$?	9·3 9·3 9·4	9·3	About $9\frac{1}{4}$ est, ruddy. c decidedly $>b$ by a few tenths.
27	8 18	70	9·5; 9·7 est.	9·5 9·7 est.	9·6 est.	Decidedly red. Brighter than c. c 2 tenths or so $>b$.
1878.						
Jan. 28	7 55	70	$a+8$ ...	8·9	8·9	9 mag. est.; fine red orange colour. c to my eye decidedly brighter than b.
30	8 40	70	$a+8$; $c-7$...	9·0 9·0	9·0	Fine ruddy tint [a assumed 8·2, c assumed 9·7]. c certainly $>b$.
Feb. 14	8 5	70	$a+8$; $c-7$...	8·9 9·0	8·95	Fine ruddy tint. Moonlight. Gauged 9·2 mag.
Mar. 5	7 20	70	$=c$?... ...	9·7	9·7	Gauged mags. of comp. stars. $a=8·2$. Clouds interrupted obs. S fine red. About $1\frac{1}{2}$ mag. less than a.
12	7 40	70	$a+15=c$? ...	9·7 9·7	9·65	Fine red. About equal to, perhaps a little brighter than, c. Full aperture and also 4 inches. Obsd. among clouds.
15	7 55	70	... ...	9·7 gauged	9·7	Rather brighter than c; fine orange red. c 9·7, 9·8; b 10·0 gauged.
16	8 20	70	$c-0-1$? ...	9·7 9·6	9·65	Fine ruddy. c gauged 9·7, 9·8; b 10·0 9·9.
Apr. 3	8 10	89	$\frac{1}{2}(c+d)$ ...	10·2 10·2	10·2	Fine red. Flaring. Very bad definition.
1879.						
Jan. 15	10 30	70	$a+15$; $c-2$	9·6 9·5	9·55	Fine pale red. A bright 10 mag. est. c 3 tenths or so $>b$. S follows a by 27 sec.; c follows a by 40 sec.; b follows a by 41 sec.
22	10 20	70	... ...	9·75 est.	9·75	Ruddy decidedly. About $=c$. $c2>b$.

S Orionis—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1879. Feb. 12	h m 8 0	70	$a+8$; $c-8$...	8·9 8·9	8·9	Fine rose red. 9 mag. est.
24	8 10	70	$a+8$; $c-8$...	8·9 8·9	8·9	Fine pale red. My est. of mags. of comparison stars in Var. Star Comp. ✶✶ mag. book [same as in map at beginning of this vol.] about correct.
Mar. 6	7 10	70	$a+7+8$; $c-8-9$	8·8 8·9 8·9 8·8	8·85	Ruddy. Bright moonlight.
13	8 0	70	$a+8$; $c-8$...	8·9 8·9	8·9	Fine red.
29	7 40	70	$a+8+9$; $c-8-7$	8·9 9·0 8·9 9·0	8·95	Ruddy. Stars low.
Oct. 6	13 15	115	... ...	...	...	Not seen; less than *e* or *f*.
15	11 30	191	... ...	12 or 12·3	12·3?	*g* pretty fairly seen at times. Stars low and bad definition. *S* fairly seen at times. Cold wind from north.
25	11 35	115	$f+1$; $g-1$...	11·7	11·7	Tolerably clear.
Nov. 5	11 20	191	$e+2$; $g-2$; $=f$	11·6 11·6 11·6	11·6	Clear sky.
13	10 15	115	$=e$	11·4	11·4	Clear.
18	10 30	115	$d+5$; $e-2$...	11·2 11·2	11·2	*e* 11·4, *f* 11·6, *g* 11·9, 12·0 est.
Dec. 1	10 50	115	$d+0+1$; $e-6$	10·7 10·8 10·8	10·8	Ruddy distinctly.
2	11 20	115	$d-0-1$ ...	10·7 10·6	10·65	Ruddy. Certainly not less than *d*. *c* 2 tenth > *b*.
10	11 30	191	$d+1$ ...	10·8	10·8	Ruddy. I think barely equal *d*.
16	9 5	191	$d-0-1$ ...	10·7 10·6	10·65	
26	8 20	70	$c+4$; $d-6$...	10·1 10·1	10·1	4½ inches aperture. Fine red. $b=c+3+4$? Bright moonlight.
29	10 15	70	$c+2+3$; $=b$	9·9 10·0 9·9	9·9	$b=c+2+3$. *S* red.
1880. Jan. 2	10 20	70	$=b$	9·9	9·9	Fine ruddy.
12	11 45	115	Barely $=c$? ...	9·8?	9·8?	Ruddy.
19	10 0	70	$c-2$ ...	9·5	9·5	Orange red.
20	7 55	70	$c-1$? ...	9·6	9·6	With full aperture *S* decidedly > *c*, 2 or 3 tenths. With aperture reduced to 3 inches the two seem more nearly equal.
26	8 20	70	$c-2$ ...	9·5	9·5	Ruddy orange.
28	11 0	70	$c-2-3$ ...	9·5 9·4	9·45	Observation difficult in haze.
29	10 5	70	$c-2$ ...	9·5	9·5	Fine orange red.
Feb. 4	10 15	70	$b-3$; $c-2$...	9·6 9·5	9·55	*c* slightly but decidedly > *b*. *c* gauged 9·7 9·8, *b* 9·9. *S* coppery red 9·6 9·7 gauged. *c* not more than 0·1 > *b*? ruddy slightly.
8	9 0	70	$c-3$ ...	9·4	9·4	*c* 2 > *b*. *S* fine red.
Mar. 13	8 30	70	$a+12$; $c-3-4$	9·3 9·4 9·3	9·3	Fine orange red. *c* 2 > *b*.

S Orionis—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1880.	h m					
Mar. 15	8 30	70	$c-3-4$ ...	9·4 9·3	9·35	Orange red. $c2>b$. c about equal to x.
25	8 0	70	$a+10$; $c-6$	9·1 9·1	9·1	Fine red. $c2>b$.
29	8 10	70	$a+10$; $c-6$	9·1 9·1	9·1	Fine pale carmine red. 9 mag. est. $c2>b$.
Nov. 2	13 40	115	... ...	13±	13±?	Feebly glimpsed.
Dec. 2	11 15	115	$h-3$ ...	12·2	12·2	$12\frac{1}{4}\pm$. Rather brighter than h.
18	8 25	115	$=e$	11·4	11·4	Moonlight and haze. $c2>b$.
24	7 55	115	$e-1$; $d+6$...	11·3 11·3	11·3	
30	10 20	115	$e-3$; $d+4$...	11·1 11·1	11·1	$b=c+2+1$.
1881.						
Jan. 7	8 10	115	$d+1$... ...	10·8	10·8	Decidedly ruddy.
Feb. 15	8 0	70	$b+4$; $d-4$...	10·3 10·3	10·3	Fine ruddy colour. c 2 or 3 tenths $>b$. So too in finder.
28	8 0	...	$b+3$; $d-5$...	10·2 10·2	10·2	Fine ruddy tint.
Mar. 19	7 18	70	$=c$	9·7	9·7	Fine carmine red.
Apr. 4	8 50	70 115	$=d$; $d-2$?	10·7 10·5?	10·6	Certainly less than either b or c. $c=b-2$, certainly brighter than b.
7	8 50	115	$=d$? ...	10·7?	10·7?	$c2>b$. S and d seem of about same mag., but stars low and moonlight, which makes obs. difficult and uncertain.
9	7 50	115	$d-2$? ...	10·5?	10·5?	Twilight and moonlight. About as much $>d$ as c is $>b$. Slightly ruddy orange. Definition poor.
Oct. 17	13 23	115	... ...	12·0	12·0	Rather less than g, greater than h.
Nov. 19	10 5	191	$=h$?... ...	12·5	12·5	c 1 or $2>b$.
Dec. 13	8 15	115	Glimpsed, less than g	Less than 11·8	<11·8	Glimpsed. Clouds began to come over.
21	10 24	115	$=h$	12·5	12·5	A clear sky.
23	10 10	...	$\frac{1}{2}(g+h)$ ...	12·1	12·1	
1882.						
Jan. 7	8 37	191	$g+4$; $h-3$...	12·2 12·2	12·2	c a tenth or so $>b$.
Feb. 11	10 0	115	$e+1$? ...	11·5	11·5	Barely $=e$?
20	8 50	115	$d+4$; $e-3$...	11·1 11·1	11·1	Ruddy tint. c a tenth or so brighter than b.
Mar. 3	7 54	115	$d+3$ ...	11·0	11·0	Fine ruddy, Obsd. with 4-in. aperture. With full aperture more nearly equal d.
17	9 3	115	$d+3$; $e-4$...	11·0 11·0	11·0	Decidedly red.
Apr. 4	8 20	70	$=d$	10·7	10·7	
8	8 35	115	$=d$	10·7	10·7	Ruddy.
1883.						
Jan. 5	8 30	191	... ...	13·0	13·0	Much less than h, slightly $>k$. $c2>b$.
Feb. 3	7 45	191	$=k$? barely $=k$?	13·3 13·5	13·4	$c=b-2$.
23	7 50	110	$k-0-2$? ...	13·3 13·1	13·15	$c2>b$.
Mar. 16	8 0	110	$f+3$; $=g$ ...	11 11·8	11·9	(g hardly 11·8?)

S Orionis—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1883.	h m					
Mar. 30	7 55	110	... ...	...	12·0	Hardly so bright as *g*.
Apr. 4	9 0	110	$=g$? barely $=f$?	...	11·8	Low, and obs. uncertain.
Nov. 26	11 20	115	$d+3$; $c-4$...	11·0 11·0	11·0	$c\ 2>b$.
1884. Jan. 19	8 20	70 115	$g+4$; $h-3$...	12·2 12·2	12·2	Between *g* and *h*. Abt. 12¼ mag. $c=b-1-2$.
Nov. 22	9 10	115	$d-7$; $b+1$...	10·0 10·0	10·0	$b=c+2+3$. Stars rather low.
28	9 15	70	$=c$	9·7	9·7	Ruddy. $b=c+2$.
Dec. 4	8 37	70 115	$=c$; $b-2$ ...	9·7 9·7	9·7	
9	9 5	115	$f-7$; $b+1$ ...	10·0 10·0	10·0	Decidedly ruddy.
15	8 47	70 115	$b+2$; $d-6$...	10·1 10·1	10·1	Ruddy.
1885. Jan. 6	11 15	115	$=d$	10·7	10·7	Ruddy.
1886. Mar. 11	8 30	70	$d-2\pm$ ...	10·5	10·5 ±	Ruddy.
Nov. 2	10 15	115	$c+1$; $b-1$ (?)	9·8 9·8	9·8	Ruddy. Obs. a little uncertain.
16	9 50	70	$c+1$; $b-1$...	9·8 9·8	9·8	Fine red.
18	10 10	70	$=b$	9·9	9·9	Very ruddy.
Dec. 1	8 50	115	$c-1$ ...	9·6	9·6	Orange red.
16	9 0	70	$c-1-2$; $b-3-4$	9·6 9·5 9·6 9·5	9·55	$c=b-2$. *S* certainly rather brighter than *c*. Clear orange red.
18	8 25	(70?)	$c-2$; $b-4$...	9·5 9·5	9·5	$b=c+2$; *S* orange ruddy. *S* 9·5. 9·6 gauged.
27	7 20	70 115	$c-2$; $b-4$...	9·5 9·5	9·5	Very poor definition. Orange red.
1887. Jan. 1	8 0	70	$c-3-4$ ...	9·4 9·3	9·35	9·3·4 gauged. $c=b-2$. Adopted 9·7. *S* orange red. Full colour. *c* 9·7 gauged.
12	8 45	70 115	$a+9$; $c-7$...	9·0 9·0	9·0	9·0 gauged. (Also *a* 8·1 *c* 9·7) fine orange red. Very bright.
20	7 0	70	$a+7+8$; $c-8-9$	8·8 8·9 8·9 8·8	8·85	8·8 gauged. Orange red.
25	8 30	70	$a+7$; $c(9·7)-9$	8·8 8·8	8·8	8·8 gauged. Ruddy orange tint. *a* gauged 8·1.
Feb. 1	7 0	70	$a+7$; $c-9$...	8·8 8·8	8·8	Gaugings *a* 8·1, *S* 8·8, *c* 9·7, *b* est. $=c+2$. *S* carmine red with slight orange tint.
7	8 25	70	$a+8$; $c-8$...	8·9 8·9	8·85	8·8 gauged, *a* gauged 8·1. *S* orange red. Not sensibly fainter than on Feb. 1?
8	8 10	70	$a+7·5$ ...	8·85 8·85	8·85	*S* gauged 8·8, 8·9, *a* 8·1. *S* fine orange red.
12	8 40	70	$a+8$; $c-8$...	8·9 8·9	8·9	8·9 gauged, red orange tint.
14	8 30	70	$a+9$; $c-7$...	9·0 9·0	9·0	9·0 gauged. *a* gauged 8·1, *c* 9 7. *S* orange red; full of colour.
16	9 0	70	$a+9$; $c-7$...	9·0 9·0	9·0	*a* gauged 8·0, 8·1, *c* 9·7, *S* 9·0. Clear red, with orange tinge. *b* gauged 9·9 10·0 $=c+2+3$.

S Orionis—continued.

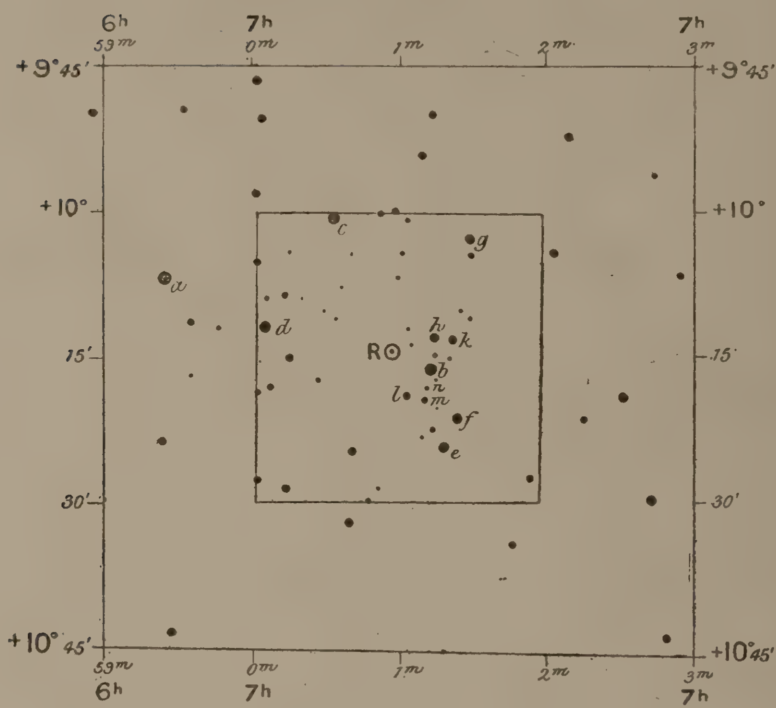
Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1887.	h m					
Feb. 21	8 20	70	$a+11$; $c-5$	9·2 9·2	9·2	Orange red; hazy sky, but fair observation.
25	8 5	70	$a+12$; $c-4$	9·3 9·3	9·3	9·3 gauged. Full red orange.
28	7 45	70	$a+12·5$; $c-3·5$	9·35 9·35	9·35	Orange red. Gaugings a 8·1, S 9·3 9·4, c 9·7, b 9·8? $c+1$, but slightly less than c.
Mar. 12	7 35	70	$c-2$ ...	9·5	9·5	Fine full orange red. 9·5 gauged.
16	8 15	70 110	$c-2$ ...	9·5	9·5	Fine red.
Apr. 8	8 5	70 110	$c+5$; $d-5$...	10·2 10·2	10·2	Ruddy. Full colour. Obs. difficult and doubtful. Stars low and sky light. Full aperture and 3·7 inches.
Nov. 30	8 50	115	$d+0+1-=d$	10·7 10·8 10·7	10·7	Rather low, and moon and haze troublesome.
Dec. 5	9 55	191	$d+2$ ...	10·9	10·9	Ruddy orange.
15	8 20	191	$d+3$ ...	11·0	11·0	
1888.						
Jan. 10	8 40	115	$d+3+4$? ...	11·0 11·1	11·05	Ruddy. Doubtful observation.
Dec. 5	9 45	115	$d+2$; $e-5$...	10·9 10·9	10·9	Red. $c=b-2$; b ruddy.
12	9 0	115	$d-1$ ...	10·6	10·6	Orange red.
26	8 55	115	$d-0-1$ ...	10·7 10·6	10·65	Ruddy.
1889.						
Jan. 1	8 55	115	$=d$? ...	10·7	10·7	Not brighter than d. Full ruddy.
20	6 40	115	$=d$	10·7	10·7	Orange ruddy. Nearly if not quite as bright as d.
27	6 55	115	$d+2+1$ ...	10·9 10·8	10·85	Ruddy. $b=c+3$, b ruddy, and *decidedly less than c*.
29	8 16	115	$d+1+2$ ...	10·8 10·9	10·85	Ruddy.
Feb. 4	10 5	115	$=d$	10·7	10·7	Decidedly ruddy.
21	8 50	115	$d-0-1$ ...	10·7 10·6	10·65	Full ruddy.
Oct. 31	10 47	115 191	Glimpsed ...	...	12·5 ±	Less than g by some tenths. k not seen.
Nov. 25	10 0	115	$h+2$; $k-5$...	12·7 12·7	12·7	A bright 13 mag. est.
Dec. 24	9 0	70 115	$=f$; $g-2$ ...	11·6 11·6	11·6	
1890.						
Mar. 12	8 5	115	$d+2$; $e-5$...	10·9 10·9	10·9	Red.
15	7 53	115	$d+1$; $e-8$...	10·8 10·6	10·7	Clouds rather troublesome.
31	7 45	115	$=d$	10·7	10·7	Moonlight. Ruddy.
Nov. 1	11 10	191	$f+1$; $g-1$...	11·7 11·7	11·7	Observation difficult.
11	11 40	115	$g+2$; $h-5$...	12·0 12·0	12·0	Ruddy? $c=b-3$.
Dec. 10	10 5	115	$=h$	12·5	12·5	
1891.						
Feb. 1	10 15	115 191	$g+2$; $h-5$...	12·0 12·0	12·0	
10	8 32	191	$g+1$; $h-6$...	11·9 11·9	11·9	$c=b-2$.
18	8 18	115	$e+4$; $=g$ ...	11·8 11·8	11·8	Moonlight and hazy sky.
24	8 40	115	$=f$	11·6	11·6	

S Orionis—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1891. Feb. 25	h m 8 5	115	$e+3$; $f+1$ ...	11·7 11·7	11·7	$c=b-1$.
Mar. 3	8 15	70 115	$e+2$; $=f$ ...	11·6 11·6	11·6	$c=b-1-2$.
23	8 17	115	$d+5$; $e-2$...	11·2 11·2	11·2	Obs. difficult and doubtful.
Apr. 6	8 20	115	$d+3$... ...	11·0	11·0	Ruddy. Hazy cloud and stars low. A very doubtful observation. c not seen.
Dec. 17	8 40	115 191	$e+2$; $g-2$...	11·6 11·6	11·6	$c=b-2$.
1892. Jan. 4	8 52	191	$f+4$; $g+2$...	12·0 12·0	12·0	$c=b-2$.
7	8 27	191	$g-1$ ...	11·7	11·7	$c=b-2$; ruddy.
24	8 35	115	$g+2$; $h-5$...	12·0 12·0	12·0	$c=b-2$.
Feb. 2	8 53	191	$g+4$; $h-3$...	12·2 12·2	12·2	$c\,2>b$; c ruddy.
Mar. 30	8 30	115	$e+1$; $f-1$ ...	11·6 11·6	11·6	g 11·9; certainly fainter than 11·8. Bad definition, but clear sky. $c=b-2$.
Apr. 1	8 0	115	$e+1$; $f-1$...	11·5 11·5	11·5	Stars rather low in hazy sky. $c=b-2$.
Nov. 26	10 25	70	$=b$	9·9	9·9	Orange red.
Dec. 12	8 35	70 115	$d-5$... ...	10·2	10·2	$b=c+4$? b seems rather unusually faint.
1893. Jan. 15	7 56	115	$d+4$; $e-3$...	11·1 11·1	11·1	$c\,3>b$.
Feb. 4	8 35	115	$=f$	11·6	11·6	
7	8 0	115 200	$e+2$: $=f$; $g-2$	11·6 11·6 11·6	11·6	Hazy sky.
Mar. 25	7 55	191	$=h$? ...	12·5?	12·5?	A rather doubtful observation. $c=b-2-3$.

Mr. Knott's Diagram, Epoch 1858.

R Canis Minoris.



Adopted magnitudes of Comparison Stars :

a	=	7·9	*g*	=	10·3
b	=	8·3	*h*	=	10·9
c	=	(9·1)	*k*	=	11·2
d	=	(9·2)	*l*	=	11·6
e	=	(9·3)	*m*	=	12·3
f	=	9·7	*n*	=	13 ?

Several stars variable.

R Canis Minoris.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 2539 *R Canis Minoris*, R.A. for 1900·0 = $7^h\ 3^m\ 13^s$, Decl. = $+10°\ 10'·9$.
Annual Variation $+3^s·30$ and $-0'·09$.
R.A. for 1855·0 = $7^h\ 0^m\ 44^s$, Decl. = $+10°\ 14'·9$.
Redness = 5·5. Max. mag. 7·2 − 7·9. Min. = 9·5 − 10·0.
$M - m = 130^d$.
Maximum, 1859 February 13 = 2400089^d (Julian).
Period = $337^d·7$.

(From nineteen observations of max. and two of min., including observations in 1796, 1822, 59–95.)

Discovered at Bonn, 1855. Light-curve flat at max. Observations of Lalande and Bessel are harmonious with the new elements.

R Canis Minoris.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1862. Feb. 8·3		60	$a+2$; $b-5$; $d-15$	8·1 7·8 7·7	7·9	Fine pale red. Fine night. Bright moonlight.
Apr. 3·3		60	$b+3$; $d-2$ ...	8·6 9·0	8·8	Fine red.
1863. Jan. 8		60	$a+3$; $b-5$ ...	8·2 7·8	8·0	Bad evening. *R* a fine red.
23		60	$=a$; $b-3$ ...	7·9 8·0	7·95	Very fine pale red.
26		60	$a+4$; $b-3$ ...	8·3 8·0	8·15	Very bad night.
27		60	$a+3$; $=b$ ...	8·2 8·3	8·25	Fine red.
Feb. 12		60	$b+1$	8·4	8·4	Beautiful ruby colour.
Mar. 11		60	$d+2$; $e+1$; $f-1$	9·4 9·4 9·6	9·5	
24		60	$=f$	9·7	9·7	Fine pale red.
31		60	$f+2$	9·9	9·9	
Apr. 4		60	$f+2$; $g-3$ ...	9·9 10·0	9·95	Ruddy.
Nov. 10·4		60	$a-2-3$	7·7 7·6	7·65	Near maximum. Fine red.
1864. Dec. 1·3		...	$b-1$	8·2	8·2	Fine red.
1865. Jan. 20·3		60	... ...	...	9·3	
Feb. 10·3		...	... ...	...	9·5 ±	Decidedly red.
20·3		...	... ...	9·8 10·0	9·9	
Nov. 3·5		70	$b-0-1$	8·3 8·2	8·25	Fine ruddy hue.
15·5		70	$b+2+1$	8·4 8·5	8·45	Fine red colour.
Dec. 14·3		70	$b+10$; $f-3$ ...	9·3 9·4	9·35	Fine red. (*Note.*—In the original obs. in the *Journal* the light ests. are "$b+10$; $e-3$"; e is, I believe, a mistake for f. The correctn. makes the ests. consistent.)
18·6		70	$e+2$; $=f$; $b+12+14$	9·5 9·7 9·5 9·6	9·6	Fine red, deeper in colour than *S*.
1866. Jan. 6·4		70	$=f$	9·7	9·7	Fine red. e considerably $>f$.
12·3		70	$=f$	9·7	9·7	Decidedly red.
23·4		70	$f+2$; $g-3$ ...	9·9 10·0	9·95	Very red.
Feb. 2·3		70	$f+4$; $=g$; $h-6$	10·1 10·3 10·3	10·2	Very red.
7·4		70	$g+2$; $h-4$ ...	10·5 10·5	10·5	Fine red.
17·4		70	$g+2$; $h-4$ ...	10·5 10·5	10·5	Fine crimson. R² of Admiral Smyth's chromatic scale.
21·4		70	$g+3$; $h-3$ ...	10·6 10·6	10·6	Red.
Mar. 10·3		70	$g+1+2$; $h-5$ ...	10·4 10·5 10·4	10·4	Red.
Apr. 4·4		70	$f+3$; $g-3$ ...	10·0 10·0	10·0	Fine red.
13·4		70	$e+1$; $f-5$; $g-10$	9·4 9·2 9·3	9·3	Fine pale carmine.
20·3		70	$b+5+6$; $f-8-9$	8·8 8·9 8·9 8·8	8·85	Fine red. Crimson.
25·3		70	$b+5$	8·8	8·8	Fine red.
May 4·3		70	$b+0+1$	8·3 8·4	8·35	Ruddy.

R Canis Minoris—continued.

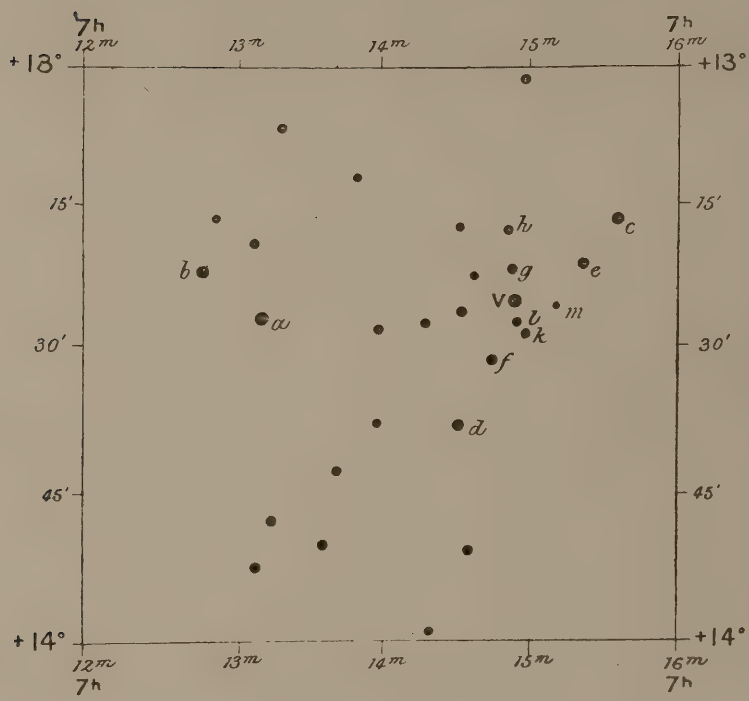
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866. Oct. 22·6		70	$b+1+2$	8·4 8·5	8·45	Fine red.
Nov. 6·5		70	$b+5$; $f-9$ ...	8·8 8·8	8·8	Fine red. Past max.
13·4		70	$b+4$; $f-10$ ...	8·7 8·7	8·7	Fine red.
27·4		70	$e+2$; $f-2$ ...	9·5 9·5	9·5	Fine red.
Dec. 7·3		70	$e+2$?; $f-2-3$...	9·5 9·5 9·4	9·5	Fine red,—a fine colour.
19·3		70	$=f$	9·7	9·7	Decidedly red. A fine colour.
29·5		70	$f+3$; $g-3$ ...	10·0 10·0	10·0	Fine carmine.
31·4		70	$=g$	10·3	10·3	Fine carmine. 6 in. aperture on telescope.
1867. Jan. 4·3		70	$g-0-1$	10·3 10·2	10·25	Fine red.
11·3		70	$g-2$; $f+4$ ...	10·1 10·1	10·1	Fine carmine. Gauged mags. of some of comp. stars in finder as follows: $b=8·2$, $e=9·29·3$; $f=9·6$; $g=10·2$.
Feb. 4·3		70	$g+2+3$; $h-3$ ...	10·5 10·6 10·6	10·6	Fine red.
14·3		70	$f+4$; $g-2$ ...	10·1 10·1	10·1	Fine red. Past minimum?
20	h m 7 0±	70	$e+3+4$; $=f$ ...	9·6 9·7 9·7	9·7	Fine red.
Mar. 2	...	70	$e+2+3$; $f-2$ ..	9·5 9·6 9·5	9·5	Fine clear red.
4	12 0±	70	$e+1·5$; $f-2·5$ ...	9·45 9·45	9·45	In Journal $R=$ "$\frac{1}{2}(e+f)$ rather nearer e." Fine red.
1868. Feb. 6	10 35	70	$f+1$; $g-4$ ...	9·8 9·8	9·8	Fine clear red.
11	11 30±	70	$=f$	9·7	9·7	Fine clear red.
Nov. 5	11 45	70	$=h$	10·9	10·9	Certainly ruddy.
Dec. 19	8 30	70	$=h$	10·9	10·9	
23	8 35	70	$g+3$; $h-3$ ...	10·6 10.6	10·6	Clear and decided red.
1869. Jan. 5	9 5	70	$g+0+1$; $h-5$ ...	10·3 10·4 10·4	10·4	Clear red, a pure and fine colour.
19	12 15	70	... ...	9·5 est.	9·5 est.	Clear full red. Brighter than f.
Feb. 12	8 5	70	$b+6$	8·9	8·9	Fine clear carmine.
18	10 15	70	$b+5$; $f-9$ ...	8·8 8·8	8·8	Fine clear red.
27	8 25	70	$a+5$; $b+1$ ...	8·4 8·4	8·4	Clear carmine. In finder (2 in. ap.) R 2 tenths $\pm < b$.
Apr. 1	8 30	70	$a+2$; $b-2$ ...	8·1 8·1	8·1	Clear copper red.
30	9 5	70	... ...	7·5 est.	7·5 est.	Certainly brighter than a and about $\frac{3}{4}$ mag. $> b$. Ruddy orange. Not so red as I have often seen it.
Dec. 24	8 10	70	$=f$	9·7	9·7	Clear red. $9\frac{3}{4}$ est.
1870. Jan. 5	8 45	70	... ...	9·3 est.	9·3	Clear ruby red. Carefully estimated 9·3. Some tenths $> f$.
Apr. 2	8 0	70	... ...	7·7 est.	7·7	Some tenths $> b$. Coppery. Clear colour.

R Canis Minoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871. Jan. 12	h m 8 15	70	$a+1$; $b-3$ ...	8·0 8·0	8·0	Ruddy orange tint.
1872. Mar. 5	8 55	70	$a+1$; $b-3$ ...	8·0 8·0	8·0	Fine red.
1877. Jan. 20	10 15	70	$f+3$; $g-3$ ...	10·0 10·0	10·0	Decidedly ruddy. 10 ± est.
Feb. 16	10 45	70	$=h$	10·9	10·9	Slightly ruddy.
Nov. 14	11 0	70	$b+5$; $f-9$; $e-5$	8·8 8·8 8·8	8·8	Clear pale red.
Dec. 27	8 45	70	$f+3$; $g-3$ ...	10·0 10·0	10·0	Red. About 10 mag.
1878. Feb. 14	8 40	70	$g+4$; $h-2$ ...	10·7 10·7	10·7	Observation a little doubtful.
Mar. 15	8 45	70	$e+4$; $=f$	9·7 9·7	9·7	Orange red.
1879. Mar. 6	9 45	70	... ...	9·5 est.	9·5	Rather brighter than f (9·7). Ruddy.
Dec. 16	11 5	70	$f+6$; $=g$; $h-6$...	10·3 10·3 10·3	10·3	Certainly red.
1882. Mar. 4	8 20	70	$=a$	7·9	7·9	Ruddy decidedly.
1883. Feb. 16	8 50	70	$a+2$; $b-2$ ...	8·1 8·1	8·1	Full yellow with rosy flush.
26	9 50	70	$a-2$	7·7	7·7	Red. Fine colour.

Mr. Knott's Diagram, Epoch 1850 ?

V Geminorum.



Magnitudes of Comparison Stars :

			b				
a	=	7·8	w	g	=	11·6	
b	=	8·1	x	h	=	12·6	
c	=	8·4	y	k	=	13·2	
d	=	9·1	z	l	=	13·4	(Bax. Jun., 13 3)
e	=	9·9	ϕ	m	=	13·7 ?	
f	=	11·2 (var. ?)					

b letters attached to stars by Mr. Joseph Baxendell, Jun.

[There is some confusion with regard to stars x and y : see notes 1883 April 4 and 7 ; 1887 Feb. 12 and 15.—H. H. T. Ed.]

V Geminorum.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 2625 *V Geminorum*, R.A. for 1900·0=$7^h\ 17^m\ 34^s$, Decl.=+13° 17′·0.
Annual Variation=+3^s·37 and−0′·11.
R.A. for 1855·0=$7^h\ 15^m\ 2^s$, Decl.=+13° 21′·9.
Redness=2·8. Max. mag. 8·2—9·1. Min.=12·0−14·0.
M−m=132^d.
Maximum, 1880 Feb. 8=2407754^d (Julian).
Period=276^d.

(From twelve observations of max. and three of min., including observations in 1857 80–86, 92–95.)

Discovered by BAXENDELL, 1880; confirmed by KNOTT and CHANDLER.

V Geminorum.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1880. Jan. 30	h m 8 0	...	... ...	8·7 8·8	8·75	Perhaps slightly ruddy. Certainly slightly ruddy when looked at after [White Star] $7^m 8$ (*a*). A star (not in D.M.) $9^m\cdot5$ precedes D.M. + 13° 1648 by 13^s on parallel. V. precedes D.M. + 13° 1655 ($8^m\cdot4$) by $39^s\cdot5$, 7′·5 further north. Gaugings, 1648, 9·5; 1650, 9·3; 1652, 9·0.
Feb. 4	10 45	70	... ...	...	8·8 gauged	Certainly ruddy or orange ruddy.
Mar. 25	8 30	70 115	... ...	...	9·5	Ruddy. About equal to 9½ mag. star which follows it by about 20^s, about = D.M. + 13°, 1648.
29	8 30	70	... ...	9·5 9·4	9·45	9·5 gauged = (−1 ?) ✱ 20^s f. 9·5 gauged. 9·0 (1652) 9·0 gauged, 2nd 9·5 (1650) 9·3 gauged. Small ✱ between 2nd 9·5 (1650) and 9·0 (1652) out of line, 11·0 gauged.
Apr. 1	9 50	70	... ...	...	9·5	9·5 gauged = ✱ f., also 9·5 gauged.
20	10 30	115 191	... ...	...	11¼	11¼ est. Rather fainter than 11 of March 29. About = (rather > ?) small star s.f.
May 1	10 10	...	... ...	...	12 ±	About ½ mag. less than ✱ s.f., 12 mag. ±, gauged 12 mag. ✱ s.f. about 11½.
Nov. 2	13 35	70	9·0 − 1 ...	8·9	8·9	Decidedly red.
19	10 20	70	9·0 − 0 − 1 ...	9·0 8·9	8·95	Decidedly ruddy. 8·9, Moonlight.
Dec. 24	7 45	115	... ...	...	10·5 est.	
1881. Feb. 16	10 15	115	... ...	...	11·5 est.	
Mar. 25	10 15	115	... ...	...	11·6	11·6 gauged. 11 = 11·2 ✱ north of Bax (V.) 12·0. (But query, does this obs. refer to *V. Gem.* G.K. 28/3/83).
Apr. 4	8 14	70	... ...	...	11·6 ±	
26	9 0	70	... ...	...	11·5 est.	
Nov. 17	9 55	70	... ...	...	12 ±	Bad definition. 5^h + from meridian.
28	10 30	70	... ...	...	11·3	Hardly so bright as 11 mag. ✱ of 1880 March 29, q.v.
Dec. 29	9 0	...	... ...	...	11·2	11, 11¼ est.
1882. Jan. 6	8 57	70	... ...	...	11·2	11, 11¼ est.
Feb. 11	10 22	70	... ...	...	...	11½, 11¾ est.
Mar. 4	9 50	115	... ...	...	11¼?	11¼? Haze and cloud and moonlight.
15	10 18	70	... ...	...	11¼ ±	

V Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1882.	h m					
Mar. 17	8 50	115	10·9 gauged...	...	10·9	
Apr. 4	8 55	70	9·0+5 ...	...	9·5	Ruddy. 9·5 est.
6	9 0	70	9·0+4; 9·5−1	9·4 9·4	9·4	Ruddy tint.
20	10 0	70	= ✶9·0 ...	9·0	9·0	A decidedly ruddy tint.
Dec. 19	10 5	110	... ...	...	11	About 11 mag. A few tenths > ✶s.f.
1883.						
Jan. 5	10 25	70	... ...	...	10·8	10·8 gauged.
26	8 50	70	... ...	9·4 9·5	9·45	Distinctly ruddy.
Feb. 3	10 3	70	9·0 gauged ...	...	9·0	Orange red.
5	8 0	70	9·0 gauged ...	...	9·0	Ruddy.
13	9 0	70	$c+3$; $d-3$...	8·7 8·8	8·75	8·7 gauged. Ruddy.
16	8 25	70	$c+3$; $d-3$...	8·7 8·8	8·75	Orange ruddy. Moonlight and haze.
22	8 30	70	$c+3$; $d-3$...	8·7 8·8	8·75	8·7, 8·8 gauged. Ruddy.
23	8 45	70	$c+3$; $d-3$...	8·7 8·8	8·75	8·7 gauged. Ruddy.
24	8 30	70	$c+3$... ...	8·7	8·7	Gauged 8·7. Ruddy. So too *c*. *d* gauged 9·1, *e* 9·8.
26	10 0	70	$c+2$... ...	8·6	8·6	Ruddy. So too *c*.
28	8 45	70	$c+3$... ...	8·7	8·7	Ruddy. Hazy sky.
Mar. 5	8 10	70	$c+2+3$; $d-4$	8·6 8·7 8·7	8·65	Ruddy. (*d* assumed 9·1.)
12	10 55	70	$c+4$; $d-3-4$	8·8 8·8 8·7	8·8	Ruddy. (*d* assumed 9·1.)
16	8 33	70	$c+5+6$; $d-1$	8·9 9·0 9·0	9·0	Ruddy. About 9·0. Clear but moonlight.
22	10 20	70	$=d$	9·1	9·1	Orange red. About 9 mag.
23	8 15	70	$d+1+2$ ...	9·2 9·3	9·25	9¼ ruddy.
28	8 23	70	$d+5$; $e-4$...	9·6 9·5	9·55	9·5 gauged. Ruddy tint decided.
30	8 20	70	$d+6$; $e-2$...	9·7 9·7	9·7	9·7 gauged. Ruddy.
Apr. 4	9 54	70	$x+7$; $=e$ ...	9·9 9·9	9·9	Ruddy.
7	8 35	70	... ...	...	10·5	10·5 gauged. *d* 9·1, *x* 9·2, *e* 9·9, 10·0, *f* 11·3, *g* 11·6, *h* 12·7 (gauged). Qu. *f* var.?
Nov. 7	12 30	115	$c+4+5$; $d-3$	8·8 8·9 8·8	8·8	Orange tint.
21	10 34	70	$c+3$; $d-3$...	8·7 8·8	8·75	Orange ruddy.
26	11 35	70	$c+3$; $d-3$...	8·7 8·8	8·75	Ruddy.
1884.						
Jan. 19	8 30	115	About $=g$	11·5	11·5	
Feb. 6	8 35	191	$=h$? $g+10$?	12·6 12·6	12·6	
25	10 15	115	About $=g$? ...	11·6	11·6	A doubtful observation.
29	7 50	70	$f+2$; $g-2$...	11·4 11·4	11·4	Brightening up?
Mar. 5	8 42	115	$\frac{1}{2}(f+g)$ ...	11·4	11·4	
Oct. 24	11 55	70 115	About $=g$? ...	11·6?	11·6?	A rather doubtful observation.
28	11 35	191	About $=h$? ...	12½?	12·5?	Doubtful obs. Qu. is my obs. of Oct. 24 in error?

V Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1884.	h m					
Dec. 9	9 55	115	$f+2$; $g-2$ ...	11·4 11·4	11·4	Obs. of *g*?
17	9 10	70	$f+2$; $g-2$ ...	11·4 11·4	11·4	Obs. of *g*?
1885.						
Jan. 6	11 20	115	$f+1$; $g-3$ ...	11·3 11·3	11·3	(This obs. is of *g* probably.)
20	9 10	191	... ...	...	...	I believe my previous obs. related to *g*. If so I do not see *V*. Rather hazy.
Feb. 18	8 45	110 235	Glimpsed ...	13·7	13·7	A small speck north of *g*. I have hitherto this season observed *g* for *V*, I have no doubt.
Mar. 7	8 47	200 115	$=h$? ...	12·6	12·6	Brightening up. No doubt as to identity now.
10	9 5	...	$h+0+1$ ...	12·6 12·7	12·65	$12\frac{1}{2}$ est. ±.
27	8 35	200	$g+2$ ...	11·8	11·8	Obsd. with difficulty. A hazy sky and bright moon.
Apr. 3	8 25	115	$=g$; $f+4$ ...	11·6 11·6	11·6	Well seen.
17	8 55	115	$e+2$; $d+10$; $f-11$	10·1 10·1 10·1	10·1	
Dec. 1	10 50	115	... ...	...	13·3 ±	13·3 ± est. less than *h*. I believe I am pretty sure of identity.
15	10 10	115	$g-1$... ...	11·5	11·5	I believe the identification is right.
1886.						
Mar. 11	8 10	70	$c+4$; $d-3$...	8·8 8·8	8·8	Ruddy. 8·8 gauged.
16	8 30	70	$c+4$; $d-3$...	8·8 8·8	8·8	Orange ruddy.
Nov. 16	10 0	70	$c+4$; $d-3$...	8·8 8·8	8·8	Ruddy orange.
29	10 15	70	$c+4$; $d-3$...	8·8 8·8	8·8	Orange red.
Dec. 2	9 0	70	$c+5$; $d-2$...	8·9 8·9	8·9	Ruddy.
4	10 5	70	$c+4+5$; $d-2-3$	8·8 8·9 8·9 8·8	8·85	Ruddy.
1887.						
Jan. 1	8 45	70	$e+3$... ...	10·2	10·2	Ruddy.
12	9 0	115	$e+11$; $f-2$	11·0 11·0	11·0	
20	8 45	115	$g+1$ ...	11·7	11·7	
25	8 35	115	$g+5$; $h-5$...	12·1 12·1	12·1	
Feb. 1	7 30	110	$h+1$ ...	12·7	12·7	Gaugings *g* 11·6, *h* 12·6, *V* 12·7 12·8 gauged. *k* 13·2? *l* 13·4? *f* 11·2 11·3. Sky not quite clear.
7	8 40	115	$h+4$ ...	13·0	13·0	Bright moonlight, but clear.
8	8 30	191	$h+5$ ...	13·1	13·1	Abt. 13·1 est. 13·0 gauged *k* 13·2.
12	9 0	110	$=k$	13·2	13·2	Baxendell's star (*y*) nearly on line from *c* to *h* 10·7 ±.
15	8 22	115 191	$=l$	13·4	13·4	*g* gauged 11·7, *h* 12·4, *f* 11·3, *k* 13·1, *l* 13·4. Bax. star *y* 10·7 10·8.
21	10 5	191	$l+1+2$ ...	13·5 13·6	13·55	13·5 est.

V Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1887. Feb. 25	h m 8 15	191	$l+2$	13·6	13·6	Qu. is *g* much brighter than 12·0? gauged about 11·8. *h* 12 6.
28	8 20	...	$l+2+3$ ...	13·6 13·7	13·65	Gaugings *h* 12·6, *g* 11·8, *y* 10·5 10·6. Small star struck by line from *e* over *y* 13·0.
Mar. 2	8 55	115	$l+3$	13·7	13·7	
12	8 20	200	$l+3+4$ ...	13·7 13·8	13·75	Very faint. About 13·7 probably. Gaugings *g* 11·6, *h* 12·6, *k* 13·2, *l* 13 4, *y* 10·6.
18	8 55	200 115	$l+4$	13·8	13·8	$13\frac{3}{4}$ est.
28	9 50	191	Glimpsed ...	13·8	13·8	*g h k l* well seen. *m* seen. Very bad definition. Almost a gale. Clouds and clear spaces.
Apr. 8	8 30	191	Glimpsed ...	13·8 14	13·9	*m*, 13·7, glimpsed. *k* and *l* well seen. Bad definition and moon.
11	8 40	191	Not seen ...	Under 13·7 14	$<13·85$	*m* seen. Qu. *V* glimpsed once or twice? 14 14·5? Wind east and definition very bad.
14	9 45	191	Not seen ...	Under 13·7	$<13·7$	*l* well seen. *m* seen. 4^h past meridian.
16	8 40	191	Not seen ...	Under 14	<14	Qu. glimpsed? 14·5? *k* and *l* and *m* very clearly seen. Clear sky.
30	9 0	191 110 115	Not seen, or once or twice glimpsed?	Under 13·7	$<13·7$	*l* well seen. *m* seen. 4^h past meridian. Moon rather near, and sky not quite clear.
May 9	9 50	115 191	Not seen ...	Under 13·3	$<13·3$	*k* and *l* (13·3) seen. *m* not seen. Stars over $5\frac{1}{2}^h$ past meridian, and sky not quite clear. Clouds coming up. Fair observation. A series of cloudy skies since April 30. At $10^h\ 5^m$ sky clouded over.
10	10 10	115	... ...	...	...	6 hrs. past meridian. Stars low and only *g* and perhaps *h* seen.
20	9 50	70 115	... ...	...	...	Nothing fainter than *e* seen. Hopeless observation.
Oct. 11	12 40	70 115	$=e;\ d+8$ ...	9·9 9·9	9·9	
Nov. 30	9 55	115 191	... ...	...	11 ±	About 11 mag.? But Moon and haze so troublesome that observation is quite doubtful.
Dec. 5	9 50	191	$=l$	13·4	13·4	The observation of Nov. 30 was evidently of *g*. Sky rather hazy, *m* not seen.
15	8 40	191	$=m;\ l+3$ ...	13·7 13·7	13·7	
1888. Jan. 9	8 45	191	Less than *m*	Under 13·7	$<13·7$	Qu. glimpsed once or twice? If so about 14. *m* fairly seen at times.
10	8 30	191	Glimpsed at times	13·8 14	13·9 ±	Some tenths less than *l*. Barely $=m$? which seen at times.

V Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1888. Jan. 18	h m 8 35	115 191	Not seen. Or glimpsed once or twice?	Under 14?	< 14?	*m* pretty well seen at times. Obs. by J. Baxendell. "1887 Dec. 13 *V* glimpsed." *Birkdale Obs.*—"*z* perhaps 3 > *V*. *V* est. 13·7; 1888 Feb. 14 *V* invis. and < 13·7; March 17, *z* fully 3 > *V*. *V* est. = 13·7; April 2, *V* 13·0."
Mar. 1	7 50	191	*m*+3? ...	14·0	14·0	About 14 mag. est.
5	7 40	70 115 191	=*m*	13·7	13·7	Some tenths less than either *k* or *l*. A faint object.
21	7 15	115 191	*l*+2... ...	13·6	13·6	*k l* and *V* well seen.
Apr. 11	11 35	115	*g*+6; *h*−4...	12·2 12·2	12·2	Clear, but star 6 hrs. past meridian and bad definition. A high wind.
14	8 50	115	*g*+3+4; *h*−6	11·9 12·0 12·0	12·0	12·0 gauged.
26	10 0	70 115	*g*−5; *f*−1−2	11·1 11·1 11·0	11·1	Rapidly gaining light.
30	9 0	115	*e*+7; *f*−6; *g*−10	10·6 10·6 10·6	10·6	Ruddy?
May 1	10 0	70	*e*+8; *f*−5; *g*−9	10·7 10·7 10·7	10·7	Rated too high last night?
7	9 45	70	*d*+9; *e*+1...	10·0 10·0	10·0	Obsd. with full aperture and one of 3 inches.
10	9 40	70	*d*+7; *e*−1...	9·8 9·8	9·8	
Oct. 5	12 30	70 115	... ...	11½??	...	Stars like pellets of wool. Two stars seen which I think are *V* and *g*. If so, *V* (the lower of the two in the field) slightly larger than *g*. (N.B. this was NOT an obs. of *V* Gem. See next obs. The stars were probably *g* and *h*.—G. K.)
13	12 15	115	Not seen ...	Under 11·6	...	*g* seen. The star seen on Oct. 5 was probably *not V*.
19	13 0	115 191 110	Not seen ...	Under 12·7	< 12·7	*f g h* seen.
30	11 50	191	Once or twice glimpsed?	...	...	Under 13·5. *k* and *l* well seen, *m* not seen. Definition very bad, hazy.
Nov. 6	11 35	115	Not seen ...	Under 13·2	< 13·2	*k* glimpsed, *l* not seen.
Dec. 7	10 10	191	*h*+6; =*k* ...	13·2 13·2	13·2	Hazy and stars observed with difficulty.
12	8 35	115	*h*+4; *k*−2...	13·0 13·0	13·0	Obs. a little doubtful.
26	9 45	115	*g*+10; =*h*...	12·6 12·6	12·6	Not very clear.
1889. Jan. 1	8 50	115	*g*+2; *h*−8...	11·8 11·8	11·8	
20	7 20	115	*e*+5; *f*−8...	10·4 10·4	10·4	Slightly ruddy.
22	10 5	(70?)	*e*+5; *f*−8...	10·4 10·4	10·4	About 10·4 gauged.
27	7 45	70	*d*+7; *e*−1...	9·8 9·8	9·8	Ruddy.

V Geminorum—continued.

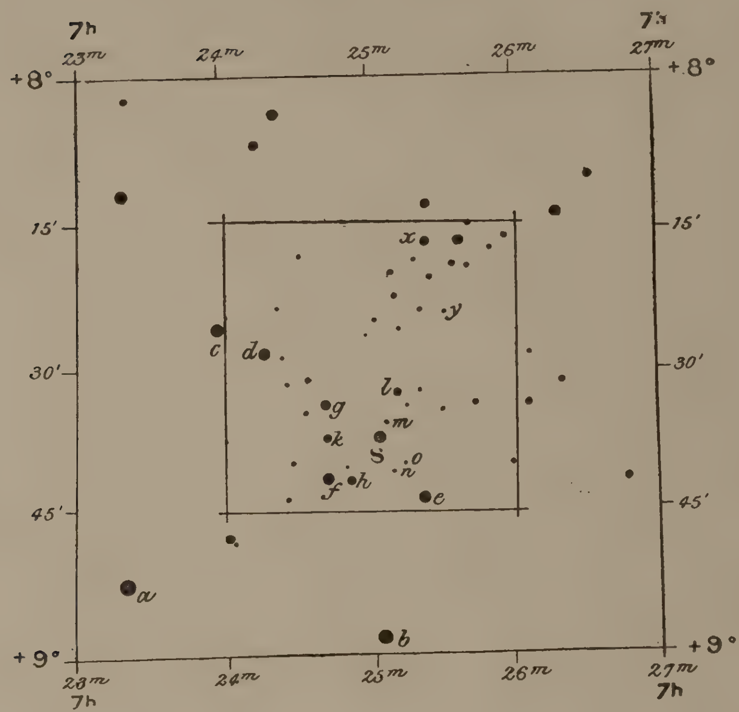
Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1889. Feb. 2	h m 8 56	70	$d+1+2$; $e-6-7$	9·2 9·3 9·3 9	9·25	Orange ruddy.
4	9 45	70	$c+7$; $=d$ ...	9·1 9·1	9·1	Orange ruddy.
7	8 55	70	$c+5$; $d-2$...	8·9 8·9	8·9	Orange ruddy.
21	8 20	70	$c+3$; $d-4$...	8·7 8·7	8·7	Orange ruddy.
Mar. 6	8 15	70	$c+2$; $d-5$...	8·6 8·6	8·6	Orange ruddy.
Apr. 11	9 0	70	$c+6$; $d-1$...	9·0 9·0	9·0	Ruddy. Very doubtful obs. Caught between clouds.
15	8 40	70	$d+5$; $e-4$...	9·6 9·5	9·55	Ruddy.
22	8 50	70	$d+6$; $e-2$...	9·7 9·7	9·7	Orange ruddy tint.
1890. Mar. 12	8 45	115	$h+6$; $=k$ ...	13·2 13·2	13·2	
Nov. 1	11 55	115 70	$e+4$? ...	10·3 ?	10·3?	f less than g? Obs. very difficult. Moon near and sky rather hazy.
11	11 33	115	$g-6$; $e+11$	11·0 11·0	11·0	Ruddy. $f=g+2$.
24	12 14	115	$g-0-1$ ...	11·6 11·5	11·55	Ruddy. Very bad definition.
Dec. 9	10 5	115 191	$h+4$; $k-2$...	13·0 13·0	13·0	Rather hazy sky.
12	10 35	110	$k-2$ ...	13·0	13·0	
1891. Jan. 1	8 45	191	$l+2$; $m-1$	13·6 13·6	13·6	
21	8 40	115 191	... ...	...	...	Not seen at all. g and h seen pretty well. Observation impossible in haze and bright moonlight.
Feb. 1	8 40	115 191	Glimpsed ? ...	Under 13·5	< 13·5	k well seen. l seen at times. Haze in sky giving very variable definition. V and m? once or twice glimpsed ? V not above 13·6. Variable sky. Obs. very difficult.
(later same evening)	10 25	191	$m+1+2$? ...	13·8 13·9?	13·85?	V and m seen at times. V not quite so bright as m.
10	8 25	191	$l+5$; $m+1+2$	13·9 13·8 13·9	13·9	Fairly well seen.
24	8 54	191	$l+3$; $=m$; $m-1$?	13·7 13·7 13·6?	13·7	Brightening up ?
26	8 25	191	$k+3$; $m-2$	13·5 13·5	13·5	$l=k$. So, too, with 115. Is it slightly var? Ask Baxendell about it.
27	8 55	115	$k+3$; $m-2$	13·5 13·5	13·5	$l=k$ or barely? Its light a little unsteady?
Mar. 3	8 25	115 191	$k+2$; $m-3$	13·4 13·4	13·4	$l=k+1$? Light unsteady? m 13·7, 3·8.
26	8 55	70 115 191	$h-6$ ...	12·0	12·0	Gauged 12·0. g about 11·7. $l=k+2$.
27	9 0	115	$=g$ or $g+1$...	11·7 11·8	11·75	Both V and g gauged 11·7. $l=k+2$.
Apr. 6	8 50	70 115	$g-5$; $e+13$	11·2 11·2	11·2	g 11·7. f about same mag. as V, 11·2. $l=k+2$. Obs. rather difficult, as sky rather hazy at times.

V Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1891.	h m					
Apr. 26	10 10	115 70	$e+1$... ...	10·0	10·0	
Dec. 17	8 54	115 191	Not seen ...	Under 11·6	<11·6	Field almost lost in moonlight and haze. *g* seen.
1892.						
Jan. 4	10 10	115 191	$g+8$; $h-2$...	12·4 12·4	12·4	Obs. difficult.
24	8 40	115	$g-1$ ...	11·5	11·5	Slightly ruddy.
27	10 40	70 115	$g-2$ ...	11·4	11·4	
Feb. 1	8 22	70 115	$g-4-5$ ...	11·2 11·1	11·15	*f* rather fainter than 11·2? Fainter than *V*.
13	11 0	115	$e+6$; $g-11$	10·5 10·5	10·5	Very ruddy.
22	8 20	70	$d+8$; $e-1$...	9·8 9·8	9·8	Ruddy.
25	9 55	70	$d+5$; $e-3$...	9·6 9·6	9·6	Ruddy distinctly.
Mar. 7	8 50	70	$c+7$; $=d$ ...	9·1 9·1	9·1	Ruddy.
14	9 0	70	$d-1$; $c+6$...	9·0 9·0	9·0	Ruddy.
28	10 27	70	$c+6$; $d-1$...	9·0 9·0	9·0	Very ruddy.
Apr. 1	9 0	70	$c+9$; $d+2$; $e-6$	9·3 9·3 9·3	9·3	Full ruddy.
4	9 5	70	$c+8$; $d+1$; $e-7$	9·2 9·2 9·2	9·2	Very ruddy.
19	9 0	70	$d+7$; $e-1$...	9·8 9·8	9·8	Ruddy.
23	8 45	70	$e-1$; $d+7$...	9·8 9·8	9·8	Orange ruddy.
Dec. 12	10 18	70	$c+4$; $d-3$...	8·8 8·8	8·8	Ruddy.
1893.						
Jan. 15	8 10	70	$d+3$; $e-5$...	9·4 9·4	9·4	Ruddy. Hazy sky. Obs. doubtful.
20	9 48	70	$e-1$... ...	9·8	9·8	Ruddy.
Feb. 4	8 50	70	$g-10$; $e+7$	10·6 10·6	10·6	
Mar. 25	8 25	191	About equal *k*?	13·2	13·2	

Mr. KNOTT'S Diagram, Epoch 1860·0.

S Canis Minoris.



Magnitudes of Comparison Stars :

a	=	7·0	*h*	=	11·5
b	=	8·1	*k*	=	11·6
c	=	8·9	*l*	=	12·1
d	=	9·4	*m*	=	12·9
e	=	9·5	*n*	=	13·5
f	=	9·6	*o*	=	13·5
g	=	10·4			

The star *x* is not in ARGELANDER, although it is as bright as the 9·10 magnitude star to the south of it. *y* is in his Chart and Catalogue, but on 1863 March 25 it was only as bright as a star preceding it on the parallel (11 mag.).—G. K.

S Canis Minoris.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 2684 *S Canis Minoris*, R.A. for 1900·0 = $7^h\ 27^m\ 18^s$, Decl. = $+8°\ 31'·9$.
Annual Variation $+3^s·26$ and $-0'·12$.
R.A. for 1855·0 = $7^h\ 24^m\ 51^s$, Decl. $+8°\ 37'·4$.
Redness = 4·1. Max. mag. 7·2 – 8·0. Min. 10·5 – 12·7.
$M - m = 164^d$.
Maximum, 1863 May 3 = 2401629^d (Julian).
Period = $+330^d·3\ E + 20 \sin (12°\ E + 30°)$.

(From seventeen observations of max. and two of min., including observations in 1856–75, 1883–95.)

Discovered by HIND, 1856. Light-curve flat at maxima. A star $9^m·5$ foll. 19^s, 4′ N.; $9^m·3$ pr. 25^s, 3′ N.

S Canis Minoris.

Date of Observation.	G.M.T.	Power.	Estimated Equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863.	h m					
Mar. 23	...	60 ?	$c-1$	8·8	8·8	Approaching max. ?
24	...	60	$b+2$; $c-2$ ...	8·3 8·7	8·5	Rather pale red.
31	...	60	$b+1$; $c-4$ ...	8·2 8·5	8·35	
Apr. 4	...	60	$b+1$; $c-4$ ...	8·2 8·5	8·35	
7	...	60	$b-2$	7·9	7·9	Low. Fairly seen.
20	...	60	$a+4$; $b-3$ ...	7·4 7·8	7·6	Fine evening.
Nov. 9	7 0	60	$=m$	12·9	12·9	
1864.						
Feb. 9	...	60	$b+1$; $c-2$ ...	8·2 8·7	8·45	Fine pale red.
10	...	60	$b+2$	8·3	8·3	
Mar. 12·3	7 0	60	$b-2$	7·9	7·9	
Apr. 1	...	60	$=a$	7·0	7·0	Ruddy.
7	...	60	$a+1$	7·1	7·1	Fine pale red.
8	...	60	$a+1+2$ ...	7·1 7·2	7·15	Bad night. *S* ruddy.
12	...	60	$=a$	7·0	7·0	Fine pale red.
14	...	60	$a+1$	7·1	7·1	Ruddy.
23	...	60	$a-1$	6·9	6·9	Fine pale red.
Dec. 1	7 0	60	$f+4$; $g-4$ ...	10·0 10·0	10·0	
1865.						
Jan. 20	7 0	60	... ...	9·1 9·2	9·15	
28	7 0	60	... ...	9·0 9·1	9·05	
Feb. 10	7 0	60	$=b$	8·1	8·1	
20	7 0	60	$b-3$	7·8	7·8	Gauged mags. of comp. stars. $a=7·0$ $7·1$; $b=8·1$; $c=8·7$ $8·8$; d 9·4 9·5; e 9·5.
24	7 0	60	$a+6+7$; $b-2-3$	7·6 7·7 7·9 7·8	7·75	
28	7 0	60	$b-3$	7·8	7·8	Gauged a 7·0; b 8·0 8·1; c 8·6 8·7; d 9·3 9·4. *S* ruddy.
Mar. 2	7 0	60	$a+6$; $b-3-4$	7·6 7·8 7·7	7·7	Gauged a 7·0; b 8·0 8·1; c 8·6 8·7; y 11 mag.
Apr. 8	7 0	60	$b-2$	7·9	7·9	In 2-inch finder. $S=b-0-1$.
21	7 0	60	$=b$	8·1	8·1	Twilight. *S* ruddy.
22	7 0	60	$b+2+3$ ...	8·3 8·4	8·35	
24	7 0	60	$b+3+4$ ...	8·4 8·5	8·45	Twilight. *S* certainly *less* than b. Ruddy.
29	7 0	60	$b+5+6$; $c-3$	8·6 8·7 8·6	8·6	Ruddy. Wind easterly. Clear, but bad definition.
May 5	7 0	60	$b+7$; $c-3$ ...	8·8 8·6	8·7	Ruddy. Clouds came up.
6	7 0	60	$b+10$; $c-2$; $e-6$	9·1 8·7 8·9	8·9	Fine pale red. R³ of Adl. Smyth's Chrom. Scale. Moonlight, y abt. 11 mag. $<g$ but $>h$. Abt. = ✱ on parallel preceding it.
15	7 0	60	$c+1+2$; $e-4$	9·1 9·0 9·1	9·1	Twilight. Obs. not very satisfactory.

S Canis Minoris—continued.

Date of Observation.		G.M.T.	Power.	Estimated Equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865.		h m					
Oct.	5	17 0	70	$k+4$; $l-1$ ...	12·0 12·0	12·0	
Nov.	3	12 0	70	$g+4$?	10·8 ?	10·8 ?	Hardly visible in bright moonlight. h not seen. $S<g$.
Dec.	12	7 0	70	$c+2+3$; $e-2-3$	9·1 9·2 9·3 9·2	9·2	Pale ruddy. Among clouds. 5½ hrs. fr. meridn.
	14	7 0	70	$c+3$; $d-1$ ...	9·2 9·3	9·25	
	18	14 0	70	$c+2$; $d-2$ ...	9·1 9·2	9·15	Fine pale red.
	30	7 0	70	$b+6$; $c-2$ ...	8·7 8·7	8·7	Fine pale red.
1866.							
Jan.	6	10 0	70	$b+5$; $c-4$ ...	8·6 8·5	8·55	
	8	10 0	70	... ...	8·5 ±	8·5 ±	
	9	10 0	...	$b+3+4$; $c-6$	8·4 8·5 8·3	8·4	
	12	7 0	70	$b+4$; $c-5$ ...	8·5 8·4	8·45	
	15	10 0	70	$a+10$; $b-1$; $c-10$	8·0 8·0 7·9	8·0	
	22	10 0	70	$a+6$; $b-5$ ...	7·6 7·6	7·6	
	23	10 0	70	$a+7$; $b-3$ ...	7·7 7·8	7·75	Fine red.
Feb.	2	7 0	70	$a+4$; $b-6$ ...	7·4 7·5	7·45	Fine ruddy.
	7	10 0	70	$a+5$; $b-6$ ...	7·5 7·5	7·5	Red. Gauged 7·4 mag. $y=10·8$ 11·0 mag.
	13	7 0	...	$a+5$; $b-6$ ...	7·5 7·5	7·5	Pale red.
	17	10 0	70	$a+4$; $b-6-7$	7·4 7·5 7·4	7·4	Pale red.
	21	10 0	70	$a+7$; $b-4$ ...	7·7 7·7	7·7	S ruddy. Past maximum ?
	23	10 0	70	$a+7+8$; $b-3$	7·7 7·8 7·8	7·8	Certainly on the wane.
	28	7 0	...	$a+8$; $b-3$ ...	7·8 7·8	7·8	
Mar.	10	7 0	70	$b+0+1$ ...	8·1 8·2	8·15	Ruddy.
	12	7 0	70	$b+1$	8·2	8·2	Ruddy.
	16	7 0	70	$b+2+3$; $c-7$	8·3 8·4 8·2	8·3	Decidedly ruddy.
Apr.	4	7 0	70	$b+13$; $c+3$; $e-2$	9·4 9·2 9·3	9·3	Slightly ruddy.
	11	7 0	70	$b+14$; $4=e$ ...	9·5 9·5	9·5	High wind and clouds.
	13	10 0	70	$e+0+1$ ...	9·5 9·6	9·55	Ruddy.
	17	7 0	114	$e+3$; $g-6$ ...	9·8 9·8	9·8	
	20	7 0	70	$e+2+3$; $g-7$...	9·7 9·8 9·7	9·7	Moon near.
	22	7 0	173	$e+2+3$; $g-6-7$	9·7 9·8 9·8 9·7	9·75	
	25	7 0	70	$e+4$; $g-5$ ...	9·9 9·9	9·9	
May	4	8 0	70	$e+7$; $g-2$ ...	10·2 10·2	10·2	Twilight and star rather low.
Oct.	22	14 0	70	$c+2$; $e-4$ ...	9·1 9·1	9·1	Certainly fine pale red.
Nov.	6	12 0	70	$b+8$; $c-1$ ...	8·9 8·8	8·85	
	13	10 0	70	$b+5$; $c-4$ ...	8·6 8·5	8·55	Fine pale red.
	27	10 0	70	$=b$	8·1	8·1	Fine pale red.
Dec.	7	7 0	70	$a+10$; $b-1$ ...	8·0 8·0	8·0	Pale red. 5 hrs. fr. meridn.

S Canis Minoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated Equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866.	h m					
Dec. 10	10 0	70	$b-2$	7·9	7·9	Pale red.
19	7 0	70	$a+4$; $b-7$ ...	7·4 7·4	7·4	Slightly ruddy.
29	12 0	70	$a+5$; $b-6$ ...	7·5 7·5	7·5	Orange tint.
30	7 0	70	$a+3$; $b-8$ ...	7·3 7·3	7·3	*S* ruddy orange.
31	10 0	70	$a+3+4$; $b-7-8$	7·3 7·4 7·4 7·3	7·35	Ruddy orange.
1867.						
Jan. 2	10 0	70	$a+1$; $b-10$ ...	7·1 7·1	7·1	
4	7 0	70	$a+0+1$; $b-10$	7·0 7·1 7·1	7·1	Ruddy orange.
8	7 0	70	$=a$; $a-?$ ...	7·0 7·0?	7·0	Orange red. Among clouds.
11	7 0	70	$a-2$; $b-12$ ...	6·8 6·9	6·85	Fine ruddy hue. In finder 2-inch aperture $=$ or perhaps $< a$.
14	9 20	70	$=a$; $b-10$ ...	7·0 7·1	7·05	Fine ruddy or orange red. In finder $S=a$.
17	8 30	70	$=a$?	7·0	7·0	Ruddy orange.
Feb. 4	8 0	70	$a+6+7$; $b-4-5$	7·6 7·7 7·7 7·6	7·65	*S* fine orange red. Evidently past maximum. Wind W.S.W.
6	10 0	70	$a+8$; $b-3$ ...	7·8 7·8	7·8	Ruddy? Not very decided colour.
14	6 30	70	$a+10$; $=b$ ...	8·0 8·1	8·05	Pale ruddy. 4-inch aperture. Moonlight.
20	6 30	70	$b+7$; $c-2$ ...	8·8 8·7	8·75	Pale coppery red. The colour not so decided as I have seen it on some occasions.
23	7 0	70	$b+7$; $c-2$ ...	8·8 8·7	8·75	Fine pale red.
28	11 30	70	$=c$; $e-5$ ...	8·9 9·0	8·95	Very decidedly red, but not a *deep* colour. In finder *S* very decidedly less than *c*. Some tenths.
Mar. 2	9 0?	70	$c+2$; $e-3$ ...	9·1 9·2	9·15	Decided colour. Pale carmine.
4	11 50	70	$c+2$; $e-3$ ...	9·1 9·2	9·15	Fine red colour. Decidedly red.
5	8 30	70	$c+3$; $e-2$ ...	9·2 9·3	9·25	Decidedly fine pale red.
Nov. 13	10 45	70	$a+10$; $b-1-2$	8·0 8·0 7·9	8·0	Pale red. 8 mag. est.
27	12 0	70	$b-2$	7·9	7·9	Light coppery red.
Dec. 3	9 30	70	$b-1$	8·0	8·0	Certainly not less than *b*. Red. Definition very bad. Snow in air.
7	10 40	70	$a+9$; $b-1-2$	7·9 8·0 7·9	7·9	Slightly ruddy. 5-inch aperture.
12	11 0	70	$b-2$	7·9	7·9	Fine pale red. Among clouds. Moon bright and near.
18	8 15	70	$b+1+2$ ...	8·2 8·3	8·25	Fine clear pale red.
22	9 0±	70	$b+3$; $c-6$ ...	8·4 8·3	8·35	Fine clear pale carmine.
31	11 20	70	$b+5$; $c-3$ ...	8·6 8·6	8·6	Pale clear red. Obs. difficult on account of flying clouds. Snow clouds apparently coming up from N.E. Wind *still*.
1868.						
Jan. 20	11 20	60	$=e$	9·5	9·5	Fine clear carmine.

S Canis Minoris—continued.

Date of Observation.	G.M.T.	Power	Estimated Equal to.	Deduced Mags.	Mean Mag.	Remarks.
1868. Feb. 6	h m 10 30	70	$=f$	9·6	9·6	Slightly red? Colour lost in hazy field brightly illuminated by the Moon.
11	11 15 ±	70	$f+5$; $g-2-3$	10·1 10·2 10·1	10·1	Pale red?
Nov. 2	11 50	70	$a+0+2$; $b-10$	7·0 7·2 7·1	7·1	Golden with ruddy cast.
5	11 30	70	$=a$; $b-11$ ...	7·0 7·0	7·0	Golden with ruddy cast.
Dec. 19	8 25	70	$c+1$; $d-4$ ...	9·0 9·0	9·0	Clear ruddy orange.
23	8 30	70	$b+9$; $c+1$; $d-4$	9·0 9·0 9·0	9·0	Clear golden with rose-coloured flush.
1869. Jan. 5	8 15	70	$d+0$; $e-1$ ...	9·4 9·4	9·4	Ruddy orange. Not so decidedly "*rose*" red as I have sometimes remarked it.
19	12 10	70	$f+6$; $g-3$ ...	10·2 10·1	10·15	Ruddy?
Feb. 2	8 0	70	$g+8$; $h-3$ ...	11·2 11·2	11·2	Decidedly red.
18	10 5	70	$l+4$; $m-4$ ...	12·5 12·5	12·5	Clear and still.
27	7 50	70	13·0 est. ...	13·0 est.	13·0 est.	
Apr. 1	8 20	70	... ...	13·3 est.	13·3 est.	Clear at times.
Dec. 24	8 4	89	Not seen ...	Under 13	< 13	Low. Several hours from meridian.
1870. Jan. 5	8 40	191	$=m$	12·9	12·9	Good observation.
Apr. 2	7 50	70	$g+8$; $k-4$ ...	11·2 11·2	11·2	I fancy it has a ruddy tinge.
1871. Jan. 12	8 5	70	Glimpsed ...	13·5 ±	13·5 ±	x and y as estimated on chart, 1863 March 25.
Feb. 8	9 0	70 89	$m+2+3$ ...	13·1 13·2	13·15	Clear.
18	8 40	70	$l+4$; $m-4$ ...	12·5 12·5	12·5	12½ mag. estimated.
23	7 40	70	$=k$	11·6	11·6	Brightening up rather rapidly.
Mar. 1	7 20	70	$g+7$; $h-4$ ...	11·1 11·1	11·1	
3	8 55	70	$g+6$; $h-5$ ...	11·0 11·0	11·0	
13	9 25	70	$g+1$	10·5	10·5	Clear carmine. 10½ est.
16	9 55	70	$f+4$; $g-4$ ...	10·0 10·0	10·0	Fine clear carmine.
18	8 53	70	$f+4$; $g-4$ ...	10·0 10·0	10·0	Fine clear carmine.
22	9 20	70	$f+3$; $g-5$? ...	9·9 9·9	9·9	Clear air. Bad definition.
24	8 40	70	$=f$?	9·6?	9·6?	Clear pale red.
Apr. 1	8 0	70	$=e$; $f-1$ ...	9·5 9·5	9·5	Moonlight. Full aperture. Not so ruddy as at times? Or is this the effect of moonlight?
6	10 50	70	$=d$	9·4	9·4	A slight pale red tinge.
Nov. 18	10 45	115	Not seen ...	Under 11·6	< 11·6	h and k seen. l glimpsed? Haze troublesome.
Dec. 12	10 50	115	... ...	13·5 est.	13·5 est.	About equal to n and o.
20	11 50	115	... ...	13·2 est.	13·2 est.	Clear.
1872. Jan. 6	9 55	70	$=m$	12·9	12·9	
Feb. 2	8 55	70	$g+6$; $h-6$ ...	11·0 11·0	11·0	Stars only seen occasionally through haze. *S* ruddy. Obs. doubtful.

S Canis Minoris—continued.

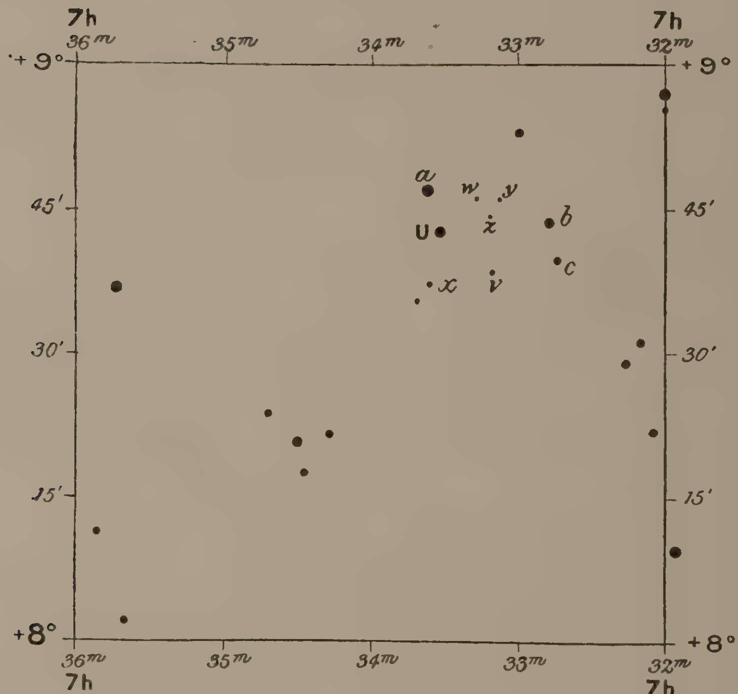
Date of Observation.	G.M.T.	Power.	Estimated Equal to.	Deduced Mags.	Mean Mag.	Remarks.
1872. Mar. 5	h m 8 45	70	$c+3$; $d-2$ ...	9·2 9·2	9·2	Pale carmine.
Apr. 10	8 50	70	$b+7$; $c-1$ ...	8·8 8·8	8·8	A pale rose tint.
13	8 23	70	$b+7$; $c-1$ ...	8·8 8·8	8·8	Rose red. Moonlight.
Oct. 28	12 20	115	A glimpse object	13±	13±	Barely $= m$. n feebly suspected. o not seen?
Dec. 4	10 25	115	$m-2$	12·7	12·7	Cold. Vision poor.
7	11 20	115 191	$k+4$; $m-9$ ...	12·0 12·0	12·0	12 mag. est.
1873. Jan. 2	9 5	70	$=g$	10·4	10·4	$10\frac{1}{2}$ est.
24	8 55	70	$=f$	9·6	9·6	Slightly ruddy?
28	8 56	70	$=d$; $f-2$ ...	9·4 9·4	9·4	Delicate rose red.
1876. Nov. 17	11 50	70	$a+3$; $b-8$ ...	7·3 7·3	7·3	Delicate pale red.
1877. Jan. 17	12 35	70	$c+2$; $d-3$; $e-4$	9·1 9·1 9·1	9·1	Pale red.
20	10 5	70	$c+3$; $d-2$ ...	9·2 9·2	9·2	Pale ruddy. The stars x and y much as described on chart.
25	11 30	70	$c+3$; $d-2$ ...	9·2 9·2	9·2	Pale red.
Feb. 16	10 25	70	$f+5$	10·1	10·1	Pale ruddy. A faint 10 mag. est.
Mar. 30	9 10	115	$k+5$; $=l$; $m-8$	12·1 12·1 12·1	12·1	Equal to or possibly a little less than l.
Nov. 1	11 40	70	$a+3$; $b-8$ ...	7·3 7·3	7·3	Ruddy yellow.
14	10 50	70	$a+5$; $b-6$ ...	7·5 7·5	7·5	Pale red.
Dec. 27	8 30	70	$d+1$; $=e$; $f-1$	9·5 9·5 9·5	9·5	Ruddy decidedly.
1878. Jan. 28	11 15	70	$g+10$; $h-1$ ...	11·4 11·4	11·4	Clear.
Feb. 14	8 30	115	$k+6$; $l+1$; $m-7$	12·2 12·2 12·2	12·2	A faint 12 mag. est. Moonlight rather troublesome.
Mar. 15	8 30	115	$m+6$; $=n$ ...	13·5 13·5	13·5	A glimpse object. Moonlight but clear.
Apr. 25	9 0	70	$k+4$; $l-1$ ...	12·0 12·0	12·0	About 12 mag. est.
1879. Mar. 6	9 30	115	$l+2$	12·3	12·3	$12\frac{1}{4}$ est. l seen, m *not* seen. Bright moonlight. x and y much as estimated on chart. $x =$ ✱ to south of it. $y =$ ✱ preceding on parallel.
Dec. 16	10 55	70	$m+0+1$ ...	12·9 13·0	12·95	
1880 Dec. 24	9 5	115	$=m$	12·9	12·9	
1881. Jan. 3	8 50	115	$l+4$; $m-4$ ...	12·5 12·5	12·5	
Feb. 16	10 5	70	$c+4$; $d-1$; $e-2$	9·3 9·3 9·3	9·3	Orange tint.
Mar. 1	9 50	70	$=c+3$; $d-2$...	9·2 9·2	9·2	Pale red.
19	8 50	70	$=c$	8·9	8·9	Rose red.
25	8 55	70	$b+4$; $c-4$ ...	8·5 8·5	8·5	Pale red.

S Canis Minoris—continued.

Date of Observation.	G M T.	Power.	Estimated Equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881.	h m					
Apr. 4	8 40	70	$b+3$; $c-5$ ...	8·4 8·4	8·4	Red.
26	8 45	70	$b-2$	7·9	7·9	Slightly ruddy? A bright 8 mag.
Nov. 28	10 50	115	$m+3$	13·2	13·2	
1882.						
Jan. 21	8 7	70	$g+3$; $k-9$ ...	10·7 10·7	10·7	Haze very troublesome.
Feb. 11	10 18	70	$=e$	9·5	9·5	Ruddy.
Mar. 4	8 15	70	$=d$	9·4	9·4	Decidedly red.
30	9 0	70	$=c$	8·9	8·9	Red.
1883.						
Feb. 6	10 0	70	$b-1$	8·0	8·0	Fine red with orange tinge.
16	9 0	70	$a+7$; $b-4$ ...	7·7 7·7	7·7	Slight rosy tinge. A banded spectrum. Several dark bands.
26	9 40	70	$a+2$; $b-9$ ...	7·2 7·2	7·2	Pale red.
Mar. 23	8 5	70	$\frac{a+b}{2}$	7·6	7·6	Gauged 7·6. Flushed yellow, but not a decided red tint.
Apr. 4	10 0	70	$a+4+5$; $b-6$	7·4 7·5 7·5	7·5	Fine red with orange tinge.
Nov. 21	10 47	70	$c+3$; $d-2$; $e-3$	9·2 9·2 9·2	9·2	
1884.						
Feb. 2	8 40	70	$a+6$; $b-5$ ...	7·6 7·6	7·6	Fine red.
Mar. 5	9 45	70	$b-0-1$? ...	8·1 8·0	8·05	b 8·1 gauged. *S* ruddy. Decided tint.
Oct. 28	12 10	70	$c+3$; $d-2$ ...	9·2 9·2	9·2	Ruddy.
Dec. 17	9 23	70	$a+6$; $b-5$ ...	7·6 7·6	7·6	Orange ruddy.
1885.						
Jan. 6	11 5	70	$a+6$; $b-4$ ...	7·6 7·7	7·65	Fine red.
20	9 0	70	$a+4$; $b-7$ ...	7·4 7·4	7·4	Orange tint.
Feb. 5	8 30	70	$a+6+7$; $b-5-4$	7·6 7·7 7·6 7·7	7·65	Fine crimson red.
9	9 0	70	$b-1-2$ ...	8·0 7·9	7·95	Ruddy.
21	8 20	70	$b+2$	8·3	8·3	Orange ruddy.
Dec. 10	10 20	70	$a+6$; $b-5$ ...	7·6 7·6	7·6	Fine carmine red.
15	9 55	70	$a+6$; $b-5$ ...	7·6 7·6	7·6	Red.
1886.						
Nov. 17	10 30	70	$a+5$; $b-6$ ...	7·5 7·5	7·5	Pale red.
Dec. 4	10 0	70	$a+7$; $b-4$ ...	7·7 7·7	7·7	Rose red.
15	8 57	70	$=b$	8·1	8·1	Rosy red.
1887.						
Jan. 1	8 17	70	$c+2$; $d-3$ ...	9·1 9·1	9·1	
Feb. 1	8 15	70	$f+6$; $g-2$ ...	10·2 10·2	10·2	Ruddy.

Mr. Knott's Diagram, Epoch 1855·0.

U Canis Minoris.



Approximate magnitudes of Comparison Stars:

$a = 8{\cdot}3$	$w = 13{\cdot}3$
$b = 9{\cdot}0$	$x = 11{\cdot}9$ or $12{\cdot}0$
$c = 10{\cdot}7$	$y = 12{\cdot}5$
$v \doteq 11{\cdot}9$	$z = 12{\cdot}6$

U Canis Minoris.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 2735 *U Canis Minoris*, R.A. for 1900·0=7^h 35^m 55^s, Decl.=+8° 36′·8.
Annual Variation=+3^s·26 and−0′·14.
R.A. for 1855·0=7^h 33^m 28^s, Decl.=+8° 42′·2 (43′·2 ?).
Redness=5·1. Max. mag.=8·5−9·0. Min.=12·3−13·5.
M−*m*=175^d. Period=410^d.
Maximum, 1880 Feb. 14=2407760^d (Julian).
(From 6 observations of max. and 8 of min., including observations in 1880–95.)

Discovered by BAXENDELL 1879; confirmed by SCHMIDT. Period and light curve very irregular, with secondary max. and min. Elements uncertain.

The Editor has substituted for the provisional designations of the stars which occur in the early observations, the letters *a*, *b*, &c. finally settled on, nothing essential being altered thereby. He has also ventured to alter the provisional magnitudes of the Comparison Stars adopted in the early observations into those finally settled on.

The stars *x*, *y*, *z*, *w*, not at first used by Mr. KNOTT, and not inserted on his original chart, have been added to his chart for simplicity by the help of small diagrams given in his notes.

U Canis Minoris.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1879. Dec. 1	h m 11 0	70	$a+5=b$ ...	8·8 9·0	8·9	*U* precedes *DM*+8° 1848 (star *a*) by 4s·3, 3′ or 3′·3 south of it. Colour slight orange ruddy 1848+5=1846 star *b* (which is 9·0 Argel. but which I should rate more like 8·8): obs. not very satisfactory for colour, as Moon was very bright. Definition poor.
2	10 35	60 70 115	$b-0-1$ ...	9·0 8·9	8·95	*U* precedes *a* by 4s·3, 3′ south of it. *b* is 2½′ south of *a*. Bright moonlight interferes with colour estimates, but I think the colour is orange yellow as compared with *a* and *b*, which are white. *U* one-tenth > *b*.
10	10 30	70 115 191 60 & bar	$=b$ or barely 9·0 say, at times $=b$	9·0 9·2	8·9	Ruddy yellow or orange tint. Barely = *b*? *a* 8·3 gauged; white. *b* 8·9 gauged; pale yellow. *U* barely = *b* 9·0 say. Its tint a decided orange. At times very nearly equal *b*.
16	9 50	70	$b+1+2$ ...	9·1 9·2	9·15	Ruddy yellow.
	10 40	89	... ...	...	9·25	Certainly two- or three-tenths less than *b*.
26	8 10	70	$b+1+2$ ...	9·1 9·2	9·15	Bright moonlight.
29	10 20	70	... ...	9·0	9·0	Certainly orange tint. Half mag. less than *a*; barely so bright as *b*.
1880. Jan. 2	10 25	70	... ...	9·1 9·2	9·15	Orange. A tenth or two less than *b*.
19	10 10	70	$b+1+2$?? ...	9·1 9·2	9·15	Orange tint, decided colour.
26	8 45	70	$=b$? ...	...	9·0	Decided orange tint.
29	10 15	70	$b+0+1$ ...	9·0 9·1	9·05	Orange tint.
Feb. 4	10 30	70	Barely $=b$ ... $b+1$	...	9·0 9·1	Orange tint. Gauged 9·0; *b* 8·9. *a* 8·3 gauged.
Mar. 13	9 50	70	$b+3$; $a+10$	9·3 9·3	9·3	Fine orange ruddy.
25	8 45	70	$b+5$; $a+12$	9·5 9·5	9·5	Orange ruddy.
Apr. 20	10 30	70	... ...	9·5	9·5	About ½ mag. less than *b*. Ruddy decidedly, not quite so much < *b* as *b* is < *a*.
Nov. 25	10 40	70	... ...	...	10·2 ±	About 10·2 mag. est. Bad definition, visible in finder.
Dec. 24	9 0	70	$b+2$ ...	...	9·2	Ruddy orange.
1881. Jan. 3	8 35	70	$b+2$ ...	...	9·2	Ruddy orange, 9·2 gauged.
Feb. 10	8 35	70	$b+(b-a)$ ...	...	9·7	*U* and *b*, both orange tint.
28	8 15	70	$b+7$ ...	...	9·7	*b* and *U*, both ruddy orange.
Mar. 19	8 45	70	$b+5+7$ ...	...	9·5 9·7	Ruddy orange.
25	10 30	70	$b+5$ ...	...	9·5	About 9½ mag. Decidedly ruddy.
Apr. 4	8 30	70	... ...	...	9·3	9·3 gauged, ruddy orange, a very decided tint. A few tenths less than *b*.
26	8 30	70	$a+3$; $b-4$...	8·6 8·6	8·6	Fine orange ruddy. Certainly decidedly brighter than *b*. So in finder too.
Nov. 19	10 30	115	... ...	...	...	12·5 ± gauged.

U Canis Minoris—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1881.	h m					
Nov. 28	10 40	70	... ...	...	...	12·5 gauged.
Dec. 29	9 40	...	... ...	...	11·4	11·4 gauged (*c* gauged 10·9), sky not very clear.
1882.						
Jan. 6	8 50	70	$=c$	10·9	10·9	Clear bright moonlight.
9	10 10	70	$c-1$ ...	10·8	10·8	Slightly ruddy.
Feb. 11	10 10	70	$b+(b-a)$ ...	9·7	9·7	Ruddy orange.
Mar. 2	11 5	70	$b+4+5$ ...	9·4 9·5	9·45	Orange ruddy.
4	8 5	70	$b+4$... ...	...	9·4	Hazy. Clouds all over sky.
6	9 50	70	$b+4+5$ ...	...	9·45	Ruddy.
22	8 53	70	$b+4+5$ ...	...	9·45	9·5 gauged. Ruddy orange.
30	8 55	70	$b+4+5$ ...	...	9·45	Ruddy orange. So too *b*.
Apr. 4	8 45	70	$b+5$... ...	...	9·5	Orange red. 9·5 est.
Dec. 18	10 25	110	... ...	12 12½ est.	12·25 est.	
1883.						
Jan. 5	10 10	70	... ...	12·5 gauged	12·5	12·5 gauged.
26	8 45	...	... ...	...	12 ±	About 12 mag.
Feb. 16	8 35	70	... ...	...	11·6	11·6 gauged. *c* gauged 10·9.
22	8 55	70	$c+3$... ...	11·2	11·2	11·2 gauged.
23	8 50	70	... ...	...	11·2	11·2 gauged.
26	8 25	70	$c+2$... ...	11·1	11·1	
Mar. 5	8 20	70	$c+2+3$ ...	11·1 11·2	11·15	Sky very hazy. Stars *U* and *c* not well seen.
23	8 9	70	$c-2$... ...	10·7	10·7	Ruddy tint.
April 2	9 7	70	$c-2$... ...	10·7	10·7	
Nov. 7	12 40	115 70	$c-2$... ...	10·7	10·7	Ruddy.
21	10 40	70	$c+3+5$ ...	11·2 11·4	11·3	
1884.						
Jan. 24	8 40	70	... ...	...	13	13 mag. est.
Feb. 2	8 25	70	... ...	...	13·3	13·3 gauged. $x=11·8$?
Mar. 5	9 0	70	$c+7$... ...	11·6	11·6	11·12 est. Clouds coming up.
Oct. 28	12 0	70	$a+3$; $b-4$...	8·6 8·6	8·6	Orange red.
Nov. 7	11 30	70	$a+3$; $b-4$...	8·6 8·6	8·6	Ruddy. Moonlight and haze troublesome.
Dec. 9	9 48	70	$a+11$; $b+4$	9·4 9·4	9·4	Ruddy.
1885.						
Jan. 6	11 10	70 115	$c-4$? ...	10·5	10·5	10·5 ± ruddy.
Dec. 10	10 20	70	$a+3$; $b-4$...	8·6 8·6	8·6	Orange red.
15	9 45	70	$a+2+3$; $b-5-4$	8·5 8·6 8·5 8·6	8·55	Ruddy.
1886						
Nov. 16	10 15	70	$=b$	9·0	9·0	Ruddy orange, ¾ mag. less than *a*.
17	10 45	70	$=b$	9·0	9·0	Ruddy orange.

U Canis Minoris—continued.

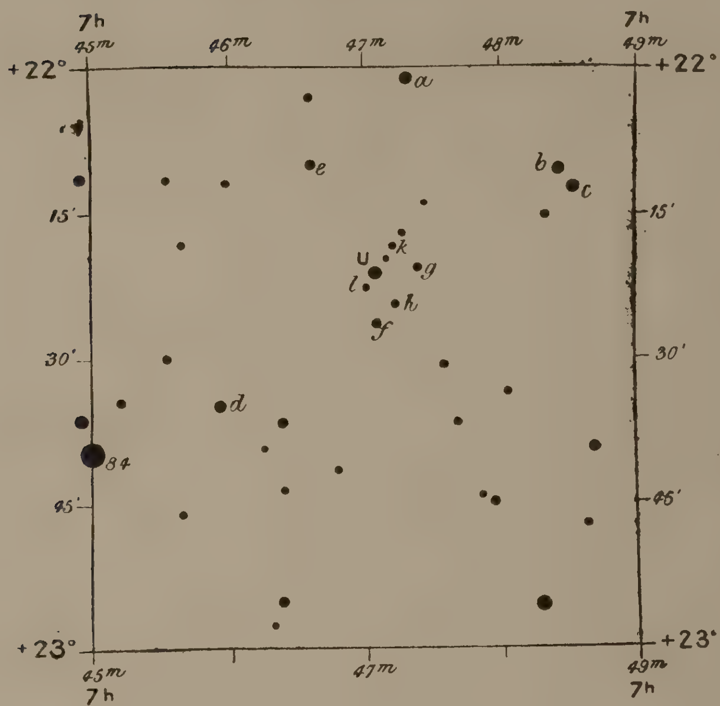
Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1886.	h m					
Nov. 29	10 25	70	$=b$	9·0	9·0	Ruddy.
Dec. 4	9 55	70	$b+1$... ...	9·1	9·1	
15	9 3	70	$b-0-1$; $a+7$	9·0 8·9 9·0	9·0	Orange ruddy.
1887. Jan. 1	8 10	70	$b-0-1$ ...	9·0 8·9	8·95	Ruddy.
25	8 43	70	$a+3$; $b-4$...	8·6 8·6	8·6	Orange ruddy.
Feb. 1	8 10	70	$a+3$; $b-4$...	8·6 8·6	8·6	8·7 8·6 gauged. Orange ruddy.
7	8 33	70	$a+3$; $b-4$...	8·6 8·6	8·6	Decided ruddy tint.
14	8 40	70	$a+4$; $b-3$...	8·7 8·7	8·7	Orange ruddy.
25	8 40	70	$a+6$? $b-1$?	8·9? 8·9?	8·9?	Ruddy. Obs. a little doubtful.
Mar. 2	10 15	70	$=b$	9·0	9·0	Ruddy.
12	8 10	...	$=b$	9·0	9·0	Ruddy.
Apr. 8	8 50	70	$b+2$... ...	9·2	9·2	Orange tint.
Nov. 30	9 40	70	$b+5+7$ ...	9·5 9·7	9·6	About as much less than b as b is than a.
Dec. 15	8 55	70	$b+7$... ...	9·7	9·7	
1888. Jan. 9	8 50	70	$=b$; $b-1$? $a+6+7$	9·0 8·9 8·9 9·0	8·95	Full ruddy tint.
18	8 45	70	$b+2$... ...	9·2	9·2	Ruddy.
Mar. 1	8 23	70	$b+7$... ...	9·7	9·7	Ruddy as much $<b$ as b is than a.
Oct. 19	13 12	115	... ...	12?	12?	Doubtful as to identification of star. (Probably NOT *U*.—G. K. 2/5/92.)
30	12 5	70	... ...	13±	13±	13 est.
Dec. 5	10 0	70	$c+12$ ...	12·1	12·1	[From a diagram given this is probably x.—H. H. T., Editor.]
12	8 55	70	$=c$	10·9	10·9	
26	9 53	70	$b+7$... ...	9·7	9·7	Ruddy.
1889. Jan. 20	6 58	70	$b+3+4$ ...	9·3 9·4	9·35	Ruddy.
27	7 8	70	$b+0+1$ ...	9·0 9·1	9·05	Orange ruddy.
Feb. 2	8 50	70	$b+3$... ...	9·3	9·3	Ruddy; gauged 9·4±.
7	8 35	70	$b+3$... ...	9·3	9·3	Ruddy.
21	8 25	70	$b+3$... ...	9·3	9·3	
Apr. 15	8 35	70	$b+(b-a)$	9·7	9·7	Ruddy.
1890. Mar. 12	9 7	70	$b+7$... ...	9·7	9·7	As much $<b$ as b is $<a$. Ruddy. Bright 10 magnitude est.
Apr. 1	8 35	70	$b+6$... ...	9·6	9·6	Nearly as much $<b$ as b is $<a$. Ruddy.
Nov. 11	11 50	70	13·3	...	...	$x=12\frac{1}{2}$?
1891. Feb. 10	8 51	70	... ...	13±	...	
26	10 5	70	... ...	12·5?	12·5?	
Mar. 26	8 40	70	$c-2$... ...	10·7	10·7	Ruddy. (The star observed on Feb. 10 was the right star.)

U Canis Minoris—continued.

Date of Observation.	G.M.T.	Power.	Light Estimates.	Deduced Mags.	Mean Mag.	Remarks.
1891.	h m					
Apr. 1	9 57	70	$c-0-1$ ...	10·9 10·8	10·85	Ruddy, doubtful obs.; cloudy.
6	8 40	70	$=c$	10·9	10·9	
Dec. 17	10 8	70	$c+3$... ...	11·2	11·2	
1892. Jan. 4	10 4	70	... ...	$12\frac{1}{2}$?	12·5?	A brighter star to south. *U* in about mid-distance, not sure of identification.
24	8 30	70	... ...	13·3	13·3	
Feb. 1	8 48	115	... ...	13·5	13·5	Well seen.
Mar. 14	9 55	115	... ...	13·3 est.	13·3 est.	
18	10 8	70	... ...	13·3 est.	13·3 est.	
28	10 5	70	$x+5$... ...	12·4	12·4	About 12·7 gauged.
Apr. 1	9 15	115	$x+5$... ...	12·4	12·4	
19	8 47	70	$c+2$... ...	11·1	11·1	Decidedly ruddy.
23	8 50	70	$=c$	10·9	10·9	Ruddy.
Dec. 12	10 5	70	$b+8$... ...	9·8	9·8	Ruddy. As much less than *b* as *b* is than *a*, or rather more. A mag. $>c$; poor definition and sky not clear.
1893. Jan. 15	8 45	70	... ...	...	11·5	11·5 est. rather doubtful obs. $>x<c$.
20	8 50	70	$=x$	11·9	11·9	12·2 gauged, as also *x*; but rather hazy sky.
Feb. 4	9 0	70	$x+8$... ...	12·7	12·7	About 13·0 est.
7	8 15	70 115	... ...	...	13·0	A tenth or two brighter than *y*. About 13 mag. Sky too hazy for gauging.
Apr. 3	9 30	115	... ...	...	13·3	A few tenths less than *y*.
5	8 50	70 115	... ...	...	13·3	Gaugings: *c* 10·7; *b* 9·0; *a* 8·3; *x* 11·9, 12·0; *y* 12·5; *z* 12·6; *w* 13·3; *v* 11·9.
21	8 50	115	... ...	...	13±	Between *z* and *w*? About 13 mag.? Very doubtful observation.
25	8 45	115	$y+5$? ...	...	13·0?	Doubtful obs.
27	9 0	191	$y+3$? ...	12·8?	12·8?	Doubtful obs. very, in bright moonlight.
29	8 55	191	$y+1$... ...	12·6	12·6	$z=y+3$ ∴ 12·8.
May 3	9 7	115 191	$x+6=y$ ...	12·5 12·5	12·5	Low and hazy sky. Obs. difficult.
5	9 7	70 115	$y-2$; $x+4$...	12·3 12·3	12·3	Clear sky.
6	9 6	115	$x+3$; $y-3$...	12·2 12·2	12·2	Pretty clear, but stars low.
Dec. 2	10 9	70	$b+1$... ...	9·1	9·1	Ruddy.
30	9 0	70	$b+4$... ...	9·4	9·4	Orange, ruddy. About $\frac{1}{2}$ $(b-a)$ less than *b*.
1894. Jan. 31	8 10	70	$=c$	10·9	10·9	

Mr. Knott's Diagram, Epoch 1865.

U Geminorum.



Magnitudes of Comparison Stars.

$a =$	8·6		
$b =$	9·3	$= m$ in Winnecke's list.	
$c =$	9·2	$= o$	,,
$d =$	10·3		
$e =$	10·6		
$f =$	11·2	$= f$	,,
$g =$	12·3	$= d$	,,
$h =$	12·3	$= e$	,,
$k =$	13·3	$= b$	,,
$l =$	13·7	$= a$	,,

U Geminorum.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 2815 *U Geminorum*, R.A. for 1900·0 = 7^h 49^m 10^s, Decl. + 22° 15′·8.
Annual Variation + 3^s·56 and − 0′·15.
R.A. for 1855 = 7^h 46^m 30^s, Decl. + 22° 22′·7.
Redness 0·0. Max. mag. = 8·9 − 9·7. Min. = 13·1.
Maximum, 1895 Oct. 28 = 2413495^d (Julian).
Period 86^d·3. Large irregularities.

Discovered by HIND, 1855. Light variation of a unique character. The star remains at or near min., about 13^m, most of the time, suddenly brightens to about 9^m·3, and diminishes again in 5–12^d to min. Irregular periods, from two to five months, average 86^d·3. For purpose of approx. prediction the epoch of last observed max. is given as epoch of catalogue. For Comparison Stars and light-scale see WINNECKE, *Ast. Nac.* 1120.

In observing this star Mr. KNOTT was in correspondence with Mr. BAXENDELL; and some extracts from letters of Mr. BAXENDELL occur in the "Remarks" column of the MS. Ledger. References of this kind which have prompted an observation by Mr. KNOTT ("Observed in consequence of a telegram," &c.) have been retained; but others merely recounting Mr. BAXENDELL'S observations, which will probably appear elsewhere, have been cut out. Such deletions bear dates 1878 May 1; 1883 Jan. 31; 1884 May 20; 1885 Jan. 5, April 9; 1886 March 3–8; 1887 Feb. 26–Mar. 2; 1888 April 17, Nov. 7; 1891 Jan. 14, May 14; 1892 Jan. 24–Feb. 4; 1892 April 1,

U Geminorum.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
	h m					
1860. Dec. 14		38 89	Under 13 mag. Not seen.	Under 13	Under 13	Air pretty good, frosty, wind N.N.E.
17		38 89 191	Not seen ...	Under 13·5	Below 13·5	A minute speck at times suspected.
18		89 100	Not seen ...	Below 13·5	< 13·5	Moon setting.
20		89	Not seen ...	Below 12·5	< 12·5	Moon troublesome. Field of telescope light.
1861. Jan. 2		89	Not seen ...	Below 13·5	< 13·5	k and l seen; $g=h$ nearly, $=h+$.
3		89 191	Glimpsed? 13·6?	13·6?	13·6?	A minute speck suspected in the place of *U* with 191, not confirmed afterwards.
4		89	Not seen ...	Below 13·3	< 13·3	One glimpse of l. Cloudy. Bad.
5	10 50	89 191	13·6 est. ...	13·6 est.	13·6 est.	A speck in place of *U* unmistakably.
7	11 0	89	Not seen ...	Below 13	< 13	Hasty observation. Cloudy. Worthless.
8	10 30	191	13·6 13·7 ...	13·6 13·7	13·65	Fine night.
10	10 0	191	13·5 est. ...	13·5	*13·5	Two stars visible.
15	8 40	89	Not seen ...	Certainly below 12·5 below 13?	< 12·5 or 13	Wind east. Definition abominable. Driving clouds.
29	7 20	89	Not seen ...	Below 13·5	< 13·5	Tolerably good.
31	8 0	89	Not seen ...	Below 13·7	< 13·7	k and l visible. Bad definition.
Feb. 6	11 0	89 191	13·5 est. ...	13·5	*13·5?	Qu. *U* or comes?
15	7 30	89	13·5 est. ...	...	*13·5?	Qu. *U* or comes? Glimpsed only.
26		89	Not seen ...	Under 13	< 13	Good definition but hazy. Still.
Mar. 1	9 30	89	Not seen ...	Under 13	< 13	
9	10 0	89	Under 13·5 ...	Under 13·5	< 13·5	A speck seen? *U*'s comes?
15		89	Not seen ...	Under 12·5	< 12·5	
16		89	Not seen ...	Under 13·5	< 13·5	Fine night.
Apr. 16	8 0	...	Not seen ...	Under 12·7	< 12·7	Moonlight, hazy.
May 14	10 0	...	Not seen ...	Under 11	< 11	Near moon, low, hazy.
Oct. 26		60	Not seen ...	Under 12·4	< 12·4	
Nov. 27		60 191	Not seen ...	Under 13·5	< 13·5	Clear, dewy, $h=g$ $(=g+1?)$
1862. Jan. 3	8 0	60	$a+4$; $b+1$...	9·2 9·4	9·3	Hazy, low, five hours from meridian.
4·3		60	$b+3$; $d-5$...	9·6 9·8	9·7	Not good.
7·3		60	$b+7$; $f-13$; $d-4$; $e-10$; $b+5$; $d-7$	10·0 9·9 9·9 9·6 9·8 9·6	9·8	Fair. Star scintillates strongly.
8·3		60	$b+5$; $d-1$; $f-13$	9·8 10·2 9·9	10·0	Moonlight, clear.
8·4		60	$e-7$... ...	9·9	9·9	*U* scintillates very strongly.
11·3		60	$e+2$; $=f$ ...	10·8 11·2	11·0	High wind. Flying clouds, moonlight. Fair observation.

* It is probable that these estimates of mag. are too high.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1862. Jan. 14·3	h m	60 89 191	Not seen ...	...	...	Only *b* and *c* seen. Moon so bright and near; neighbouring stars invisible.
16·4		60 191	Not seen ...	...	...	Bright moon too near.
24·3		191	... ...	...	13 ??	
Apr. 3·3		89	13·3; 13·4 est.	...	13·4 ±	Either *U* or close comes.
15·3		89	13·5 est.? ...	...	13·5?	Either *U* or close comes.
Dec. 20		...	Not seen ...	Below 12·5	< 12·5	Mr. Pogson's *g* and *h* well seen, but night indifferent. For note by Mr. Baxendell see my Var. star obs. book. [Mr. Baxendell writes me that *U* passed an unexpected max. a few days before Dec. 26. On that day he noted it 10·5 mag., and on the 29th it was below 12·3.]
1863. Jan. 24		102	Not seen ...	Below 13·0	< 13	Fine night.
Mar. 11		...	... ...	Under 13·7	< 13·7	Less than *k* or *l*.
12		...	... ...	Under 13·5	< 13·5	
18·4		102	$k+3$; $l+1$ ...	13·6 13·8	13·7	Adopting Mr. Baxendell's mags. for comp. stars.
19·3		102 173	Not seen. Less than *l*	Below 13·7	< 13·7	Not very clear. Cloudy at times.
21		...	Not seen ...	Below 13·7	< 13·7	
24		102	Not seen ...	Below 13·5	< 13·5	
31		102	Not seen ...	Below 12·5	< 12·5	*g* and *h* well seen. Moonlight.
Apr. 4·4		38 60 102	$b+1+0+1+1$; $a+5+6$	9·4 9·3 9·4 9·4 9·1 9·2	9·3	Bluish white. Moonlight and light clds. Est. mag. 9·4.
7·4		60	$b+4$ ...	9·7	9·7	Est. 9·6 9·8. Between clouds.
7·5		60 102	$b+3$ ...	9·6	9·6	By method of reduced apertures $U=9·5$. Fine.
13	8 30	60 102	$b+15$; $d+7$ $f-2$	10·8 11·0 11·0	10·9	Fine. By method of reduced apertures $U=10·8$.
14	9 30	...	$h-1$... ...	12·2	12·2	Gauged 12·0 mag. [Mr. Baxendell writes me that on the 11th at 8^h 40^m *U* was of 9·55 mag.!]
Oct. 23		102?	Not seen ...	Below $11\frac{1}{2}$?	< 11·5?	Field very doubtful on acct. of bright moonlight and distance from the meridian.
Nov. 9·3		102 173	Not seen ...	Below 13	< 13	5^h from meridian.
Dec. 2		...	Not seen ...	Below 12·5	< 12·5	*g* and *h* well seen.
9		...	Not seen ...	Below 13·7	< 13·7	*k* and *l* seen.
14		60	Not seen ...	Below 12·5	< 12·5	Clouds came up after this observation.
16		60	Not seen ...	Under 13·5	< 13·5	Clear.
29·5		60	$=e$; $f=2$ ...	10·6 11·0	10·8	$g=h-3$; decidedly $>h$. *U* obsd. in consequence of letter from Mr. Baxendell, who obsd. it thus: "Dec. 27, 7^h 30^m b 4 > *U*"; hence $U=9·7$.
30·45		60 102	$e+5+6$; $f+3$	11·1 11·2 11·5	11·3	*g* 3 or 4 tenths > *h*. Moonlight. Clear.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1864.	h m					
Jan. 1·5		...	$k+2$; $l-1-2$	13·5 13·6 13·5	13·5	$g=h-3$.
Feb. 13		...	Not seen ...	Under 13	< 13	
Mar. 12	8 40	173	$k+2$; $l+1$ ...	13·5 13·6	13·55	Well seen at times.
12	10 40	173	$k+3+4$; $l+1$	13·6 13·7 13·8	13·7	
16		...	Not seen ...	Below 13·3	< 13·3	Bright moonlight.
19		...	Not seen ...	Below 12·5	< 12·5	g and h *well* seen. Moonlight.
24		...	... ...	13 8?	13·8?	k and l seen.
29		...	Not seen ...	Below 13·3	< 13 3	k seen well.
Apr. 1		...	13·9 est. ...	13·9	13·9?	Visible by glimpses. k and l seen.
2		102	Not seen ...	Below 13·7	< 13·7	l seen.
7		...	Not seen ...	Below 13·3	< 13·3	
8		...	Not seen ...	Below 13·3	< 13·3	k well seen.
12		102	Not seen ...	Below 12	< 12	g and h glimpsed. Moonlight.
13		102	Not seen ...	Below 10·5	< 10·5	Moon near and troublesome.
14		60 102 173	Not seen ...	Below 13 13·3?	< 13 or 13·3?	k seen by glimpses. Moonlight.
23		102	Not seen ...	Below 13·7	< 13·7	k and l well seen.
25		60	Not seen ...	Below 13·3?	< 13·3?	
Oct. 7·4		60	Not seen ...	Under 13·3	< 13·3	k visible.
Nov. 3·3		...	Not seen ...	Under 13·7	< 13·7	l visible.
26·3		102	Not seen ...	Under 13·3	< 13·3	k visible.
28·4		102	Not seen ...	Under 13·7	< 13·7	k and l visible.
Dec. 1·3		...	Not seen ...	Under 13·5	< 13·5	
17·3		...	Not seen ...	Under 13·7	< 13·7	k and l seen. Obs. by Mr. Baxendell, "Dec. 30, 7^h 40^m b $1 > U = c$," $\therefore U = 9·2$.
1865.						
Jan. 4	7 55	60	$b+2$; $d-7-8$	9·5 9·6 9·5	9·5	At times I almost fancied $U=b$. In finder $=b$. Bluish.
4	12 30	60	$b+3+4$; $d-7$	9·6 9·7 9·6	9 6	White. Unsteady light. Twinkles much.
6·3		60	$b+5$; $d-5$...	9·8 9·8	9·8	Haze and cloud. Wind South-west.
17·3		...	... ...	Below 13·3	< 13·3	l hardly visible. Qu. U vis. by glimpses? 13·7 14 mag.? Obs. interrupted by clouds.
Feb. 28·3		60 102	Not seen ...	Below 13·7	< 13·7	l visible by fits. Haze and cloud.
Mar. 2·3		60 102	Glimpsed? ...	14?	14?	k and l visible.
Apr. 8·3		102	Not seen ...	Below 13·3	< 13·3	k visible. Moonlight.
21	8 30	60 102	$b+6+7$; $d-3$	9·9 10·0 10 0	10·0	
21	8 40	60 102	$b+7$; $d-2$; $e-5$	10·0 10·1 10·1		Twilight. By method of red. ap. U gauged = 10·0 mag.
22	8 0	60 102	$d+1+2$; $e-2-3$	10·4 10·5 10·4 10·3	10·4	Aperture reduced to 4 inches.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865.	h m					
Apr. 23·3		60 102	$d+5$; $f-3$...	10·8 10·9	10·85	More than $0^{m}·3$ between d and e, and certainly *less* than $0^{m}·6$ between e and f. e variable? U certainly decreasing.
24	8 30	...	$f+3$; $h-6-7$	11·5 11·7 11·6	11·6	g very decidedly $>h$. Some tenths; $=h-4$?
25	8 0	102	$h+1$... ...	12·4	12·4	12·5 est. $<h$.
25	10 45	102	$h+3$... ...	12·6	12·6	
27·4		60 115	Glimpsed? ...	Below 13·7	$<13·7$	k and l seen. $U<l$. e in mag. betw. d and f. Nearer to f.
Oct. 5·7		...	Not seen ...	Below 13·3	$<13·3$	k visible.
Nov. 3·5		70	Not seen ...	Below 12?	<12?	Not visible; in bright moonlight. Obs. uncertain.
15·5		...	Not seen ...	Below 12·5	$<12·5$	g and h seen. Hazy.
Dec. 12·3		70	Not seen ...	Below 13·3	$<13·3$	Less than k certainly. Among clouds.
14·3		191	Glimpsed? ...	13·8 14	14 ±	Some hours fr. merid.
18·6	...	191	Glimpsed? ...	Below 13·7	$<13·7$	Doubtfully glimpsed?
30·3	...	70 102	Not seen ...	Below 12·3?	$<12·3$?	Obs. almost impossible in haze and moonlight.
1866.						
Jan. 6·4	...	191	Glimpsed ...	14 ±	14 ±	Less than l, which was well seen. I fancied I glimpsed also the minute star near U.
8·4	...	191	Not seen ...	Below 13·7	$<13·7$	
9·4	...	...	Not seen ...	Below 13·7	$<13·7$	k and l seen.
12·3	...	...	Not seen ...	Below 12·5	$<12·5$	g and h well seen; hazy.
15	9 0	...	Not seen ...	Below 13·3	$<13·3$	k seen.
16	10 15	70 173	$k+5$; $k-5$...	12·8 12·8	12·8	Is U rather hazy? More so, I think, than its neighbours. Night brilliant, but bad definition. l well seen. [For obs. of this max. by Mr. Baxendell see *Var. Star Obs. Journal.*]
22	11 0	70	$b+1$... ...	9·4	9·4	Obs. much interrupted by clouds and rather doubtful. U certainly not $>b$.
23	9 0	70	$b+1$; $d-9$...	9·4 9·4	9·4	Among clouds.
23	12 0	70	$b+4$; $d-6$; $a+10$	9·7 9·7 9·6	9·7	I fancy U is *less* than it was 3^{h} ago. Only fancy perhaps. Gauged mags. of comp. stars as follows: $a=8·5$; $b=9·3$ est.; $c=9·2$; $d=10·3$–$10·4$; $e=10·7$. In the finder, 2-in. aperture, power 20, the difference between U and b appears *less* than in the large telescope.
24	10 15	70?	$a+3$; $b+5$; $d-5$; $f-12$	9·9 9·8 9·8 10·0	9·9	On the wane? Is U rather large for its mag.? Its light is rather dull.
29	8 15	70 153	$d+3$; $=e$ ...	10·6 10·6	10·6	Obs. doubtful, Moon very bright and near, and stars not always to be seen. g and h only seen at intervals.
Feb. 2	7 45	70?	$k+3$; $l-1$...	13·6 13·6	13·6	Stars bright but vision confused. A fresh breeze.
3	10 30	70 102 191	$l+1$... ...	13·8	13·8	Bad defn. Stars seen only by glimpses.
7	8 50	191	$l-0-1$ ...	13·7 13·6	13·65	I fancy that it is almost an easier object than l.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866.	h m					
Feb. 13	8 30	...	Glimpsed ...	14 ±	14 ±	Less than *l*.
17	10 30	173	Glimpsed ...	14 ±	14 ±	A glimpse object. *k* and *l* seen. Still, but slightly hazy.
Apr. 4·3	...	70 191	Not seen ...	Under 13·7	< 13·7	*k* and *l* well seen.
11·3	...	70	Not seen ...	Under 12·3	< 12·3	*g* and *h* seen. Haze and wind.
13	10 30	70 191	Some tenths less than *l*	14·3?	< 14·3?	A feeble glimpse object.
17	10 30	60 70	$b+4$; $d-6$...	9·7 9·7	9·7	Light unsteady. At times looks more like $b+6$; $d-4$. Star not sharply defined (*i.e.* disc not sharp). Air very clear and still.
18	11 25	60 70	$a+16$; $b+7+8$; $d-2-3$; $f-10$	10·2 10·0 10·1 10·1 10·0 10·2	10·1	Is *U* less than it was last night? I think so, very decidedly. Disc not sharply defined. Stars rather low and obs. rather interrupted by haze and cloud.
20	8 30	70	$d+4+5$; $e+2$; $f-4-5$	10·7 10·8 10·75 10·8	10·75	The light of *U* very unsteady. Moon near. $e=$ 10·9–11·0. *U* gauged 10·7–10·8.
21	9 5	70 191	$f+4$; $h-7$...	11·6 11·6	11·6	*U* almost lost in bright moonlight. Moon abt. 1st quarter and near, consequently observation *very doubtful*. *U* is certainly *less* than *f*, however.
22	8 40	102	$h+5+4$; $k-5-6$	12·8 12·7 12·8 12·7	12·75	Obs. rather difficult on account of bright moonlight and occasional haze. *U* certainly less than *h*. Its light rather unsteady. *g* 2 or 3 tenths less than *h*.
22	8 55	173	$h+4$; $k-6$...	12·7 12·7	12·7	
24	9 0	102 173	... ...	Under 13·3	< 13·3	Qu. *U* and *l* visible by feeble glimpses? Very doubtful. Bright moonlight. *k well seen.*
25	9 0	102 191	Not seen ...	Under 13·5	< 13·5	*k* pretty well seen, moonlight troublesome.
Sept. 24	14 30	70 89 156	$b+7$; $d-3$; $e-6$	10·0 10·0 10·0	10·0	*U* bluish-white, slightly hazy, and light unsteady, seems to fluctuate bet. 9·8 and 10·0 est. *g* and *h* well in view. *k* seen at times. Moonlight troublesome. (Bad weather, unfortunately, prevented my observing this star on succeeding night.)
Oct. 22·6	...	191	Not seen ...	Under 13·3	< 13·3	*k* seen.
Nov. 13·4	...	70	Not seen ...	Under 13·3	< 13·3	*k* seen.
27·5	...	70	Not seen ...	Under 13·3	< 13·3	Moon rising.
Dec. 7·3	...	89 191	... ...	Under 13·5	< 13·5	*k* well seen. Qu. with 191 is there a glimpse object near the place of *U*? *l* seen by glimpses.
10	10 15	89 191	*l*?; $l+1+2$?	13·7 13·8 13·9	13·8	There is a small star about equal to *l* or rather less, close to the place of *U*. By glimpses seen very decidedly.
19·3	...	89 191	Not seen ...	Below 13·3	< 13·3	*k* glimpsed, *g* a few tenths less than *f*.* Moonlight and defn. very bad. Obs. doubtful.
29	11 40	89 191	A glimpse object	14·0 ±	14·0 ±	*k* and *l* seen. Clear. Definition bad.
30	8 30	89 191	Nearly $=l$ ...	13·9 14·0	13·95	

* So in my Obs. book, but qu. should be less than *h*.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866. Dec. 31	h m 10 30	89 191	Glimpsed ...	14·0 ±	14·0 ±	$g = h - 2 - 3$.
1867. Jan. 2	10 35	70 89 191	$l + 1 + 2$ ...	13·8 13·9	13·85	Certainly seen. But neither l nor U steadily visible.
4·3	...	89	Feebly glimpsed	14·2?	14·2?	Considerably less than l.
8	7 35	89	Not seen ...	Below 13·3	< 13·3	Clouds coming up. k seen.
11	10 30	191	$k + 3 + 4$; $l - 1$	13·6 13·7 13·6	13·6	The small star between k and U also seen. About 14·0–14·3 mag.
11	12 30	191	$l + 0·5$ ...	13·75?	13·75?	Qu. U barely so bright as l? Considerably fainter than k.
12	7 10	70 89	Not seen ...	Under 13·3	< 13·3	k seen by glimpses.
14	9 10	89	Not seen ...	Under 13·3	< 13·3	k seen. l glimpsed occasionally? Moonlight, air disturbed.
17	8 20	70	Not seen ...	Under 12	< 12	g and h seen but not steadily. Flying clouds from N. Snow on grd. Moonlight.
Feb. 4	8 10	191	$k + 3$; $l - 1$ ...	13·6 13·6	13·6	The small star between U and k seen by glimpses.
6	11 25	89 191	Less than l ...	14 ±	14 ±	A feeble glimpse object.
14	7 ±	89	Not seen ...	Under 13·3	< 13·3	Less than k.
23	12 30	...	Not seen ...	Under 12·5	< 12·5	g and h seen.
28	12 0	89 191	Glimpsed. < l	14·3 ± ?	14·3 ± ?	The faint star between U and k glimpsed feebly. Clouds coming up.
Mar. 2	10 ?	89	Not seen ...	Under 13·7	< 13·7	
4	12 ±	70?	Not seen ...	Under 13·3	< 13·3	Clouds coming up.
5	8 50	70?	Not seen ...	Under 13·7	< 13·7	
Apr. 29	10 45	89	Feebly glimpsed?	Under 13·7	< 13·7	k seen. l by glimpses.
May 3	9 0	115	Not seen ...	Under 13·5	< 13·5	k seen. l glimpsed?
7	10 15	70 89 191	Not seen ...	Under 13·3	< 13·3	k seen. l glimpsed? Hazy.
11	9 0	70 89	Not seen ...	Under 13	< 13	k glimpsed. Moonlight and haze.
23	11 0	70 89	Not seen ...	Under 10	< 10	7¼ hrs. past merid. b and c seen. Sky clear but stars low.
Oct. 19	11 0	70	Not seen ...	Under 10	< 10	d seen. b and c bright, but Moon rising.
Nov. 23	9 5	70 89	Not seen ...	Under 12·3	< 12·3	g and h seen. 6½ hrs. fr. merid.
27	12 ±	191	Not seen ...	Under 13·7	< 13·7	l glimpsed.
Dec. 3	9 20	89	Not seen ...	Under 13?	< 13?	Certainly below 12·5, probably below 13. g and h brightly seen, and k once or twice suspected.
7	9 0	70	$b + 2$... ...	9·5	9·5	9·5 mag. est. U has a *large disk*, but not so sharp and bright as b. Stars low and moonlight troublesome.
7	10 25	70	$a + 8$; $b + 1 + 2$; $d - 9$	9·4 9·4 9·5 9·4	9·4	Full aperture } U bluish-white with an ill-defined (hazy) disk. Not so *sharp* as b. [Soft edges.]
7	10 25	70	$= b$	9·3	9·3	5-inch aperture } (see above)
12	8 10	70	$b + 2$... ...	9·5	9·5	6ʰ fr. merid. and Moon, 1 day past full, near.

U Geminorum- continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
Dec. 12	10 45	70	$b+2$; $d-8$...	9·5 9·5	9·5	Bluish-white. Among clouds.
12	11 10	70	$a+10$; $b+3$; $d-7$; $e-10$	9·6 9·6 9·6 9·6	9·6	Careful comparison. Moonlight, and filmy cloud troublesome.
18	8 0	70 89	$e+4+5$; $f-2-1$	11·0 11·1 11·0 11·1	11 05	*U* rather large for its mag., and dull. Bluish-white in colour. A clear sky.
22	8 45	89 156 191	$k+4$; $l-0-1$?	13·7 13·7 13·6	13·7	At intervals *U* seemed to flash out rather brighter than *l*, but stars rather low, and apparently slight haze occasionally. *U* when best seen bluish-white.
27	11 10	191	$l+3$... ...	14·0	14·0	The small star between *U* and *k* glimpsed. A clear sky.
31	10 55	191	... ...	14 ±	14 ±	A feeble glimpse star 14 mag. ± seen in place of *U*. *l* seen. Cold. Thermometer in observatory 25°; slight haze about.
1868. Feb. 6	10 30	70	Not seen ...	...	...	Moon too near. Only *b* and *c* seen.
11	11 5	89	Not seen ...	Under 13·3	< 13·3	Clear and still. Moon rising.
Apr. 2	8 30	191	Not seen ...	Under 13	< 13	*k* glimpsed. Moonlight and haze.
23	8 45	70	Not seen ...	Under 9·3	< 9·3	Very hazy. *b* and *c* seen.
May 14	10 15	89	Not seen? ...	Under 13·3	< 13·3	Qu. Very feebly glimpsed? Exceedingly doubtful. *l* not seen.
Nov. 2	11 40	191	Not seen ...	Under $12\frac{1}{2}$	< 12·5	Moonlight and hazy.
5	10 35	70	Not seen ...	Under 10·3	< 10·3	The field so flooded with moonlight that only *a*, *b*, *c*, and the group about *d* are visible.
Dec. 19	8 40	89	Not seen ...	Under 13·3	< 13·3	*k* seen slightly hazy.
23	8 15	191	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* not seen. Moonlight. Sky slightly hazy?
30	10 20	70 89	Not seen ...	Under 10·3	< 10·3	*d* seen, but obs. very difficult. Moon bright and near.
1869. Jan. 3	8 50	191	A glimpse object?	Under 13·7	13·7	*l* seen. I fancy at intervals I catch glimpses of both *U* and its near comes; if so both would be about 14·5 mag. Obs. doubtful. Sky not quite clear.
5	8 10	70 89 191	Not seen ...	Under 13·7	< 13·7	*l* seen. Qu. *U* feebly glimpsed at rare intervals? doubtful.
19	10 15	191	A glimpse object	14·5 ±	14·5 ±	Both *U* and its comes glimpsed; clear sky. Moon setting.
Feb. 2	7 45	191	... ...	14 $14\frac{1}{2}$	14·5 ±	Feebly glimpsed, as also its comes (Winnecke's ✱). *k* and *l* well seen at times. Slight haze at times?
4	8 45	191	Feebly glimpsed?	Under 14	< 14	*k* and *l* seen.
18	8 25	70	$b+5$; $d-5$...	9·8 9·8	9 8	Careful comparison. *U* rather dull. Bluish-white in hue.
19	6 35	70	$b+5$; $d-5$...	9 8 9·8	9·8	*U* bluish-white, Moon just past merid. and about 1st quarter. I think there is little, if any, difference noticeable from last night's estimates. Used full aperture, and also one of 4 inches. Clouds coming over.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Feb. 19	h m 8 55	70 89	$b+5$; $d-5$...	9·8 9·8	9·8	About $9\frac{3}{4}$ mag. est. White and more sharply defined than I have usually noticed it. Quite as sharply defined as *b* or *d*.
20	6 35	70	$b+5$; $d-5$...	9·8 9·8	9·8	Observed in clear intervals between clouds. Twilight and moonlight. I noticed little, if any, change since last night.
20	10 15	70	$b+6$; $d-4$...	9·9 9·9	9·9	Careful estimation with aperture of 4 inches. *U* is nearer to *d* than *b* in brightness. *U* pretty sharply defined, bluish white in hue. A little past meridian. Moon bright.
23	10 0	70 89	$b+7$; $d-3$?	10·0 10·0	10·0	Obs. doubtful; Moon bright and near, and the field of telescope flooded with light. By estimate *U* appears to be of about 10 mag., *possibly* a *bright* 10 mag. Thus for five days there has been little change in magnitude! Mr. Baxendell writes me that on the 5th inst. he looked for but could not see *U*, and noted it 'below 12·8 mag.'
24	10 0	70	$d+5$; $c+2$; $f-4$	10·8 10·8 10·8	10·8	Decreasing. Bright moonlight, but fair observation.
26	9 0	89	$h\pm$	12·3 ±	12·3 ±	Caught between clouds. Obs. tolerably certain.
27	7 5	102 191	$h+8$; $k-2$	13·1 13·1	13·1	Clear sky. *U* has rather a large disk and a hazy appearance. Colour greyish white.
Mar. 5	8 0	89 191	Glimpsed ...	Below 13·7	< 13·7	Glimpsed in clear intervals between flying snow? clouds. 14, $14\frac{1}{2}$ mag. *k* well seen. *l* seen.
Apr. 1	8 15	70	Not seen ...	Under 13·3	< 13·3	*k* seen. Hazy.
4	8 35	70 102	Not seen ...	Under 13·3	< 13·3	*k* seen. Sky rather hazy. *l* not seen.
8	8 20	70 191	Not seen ...	Under 13·7	< 13·7	*l* well seen.
30	8 45	89	Not seen ...	Under 12·3	< 12·3	*g* and *h* seen. Full twilight. Wind N.E. Definition bad.
Oct. 26	10 45	70	Not seen ...	Under 9·3	< 9·3	*a*, *b* and *c* seen, but observation worthless. Star $6^h\ 45^m$ from meridian and moon near. Cold air and *snow in air*?
Nov. 4	11 5	70 102 156	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* glimpsed painfully at intervals. Star $5\frac{1}{2}^h$ from meridian, and sky not always clear.
6	10 40	191	Not seen ...	Under 13·5	< 13·5	*k* well seen, *l* glimpsed.
10	10 30	89 191	Not seen ...	Under 13·5	< 13·5	*k* seen, *l* glimpsed. Unsteady vision.
11	10 35	89 191	Not seen ...	Under 13·3	< 13·3	*k* glimpsed. Hazy.
20	10 30	89	Not seen ...	Under 9·3	< 9·3	*b* and *c* seen. But sky rather hazy and Moon bright and near. *N.B.*—When preparing to close the observatory found I had been using an aperture of 3in.·7 only. Re-observation impossible, clouds coming up.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Nov. 28	h m 9 0	70 102	Not seen ...	Under 13·3	< 13·3	*k* seen at times. *U* 6 hrs. from meridian, and haze at times.
30	8 45	89	Not seen ...	Under 13·3	< 13	*k* glimpsed at times by fits. *U* 6^h 20^m fr. meridian. Bad definition. Cold wind from N.N.W.
Dec. 24	7 35	89	Not seen ...	Under 13·3	< 13·3	*k* seen at times.
1870. Jan. 5	8 55	89	Not seen ...	Under 13·5	< 13·5	*k* well seen. *g* very bright. It must be 11·5 or 11·8 mag.
10	7 10	89	Not seen ...	Under 9·5	< 9·5	Very hazy. A ground mist. Moonlight. A max. in Jan. 1870, observed at Madras by N. R. Pogson, Government Astronomer, printed in *Madras Merid. Circle Obs.* 1868–69–70 (Madras, 1890), 1870 Jan. 17, $9^m \cdot 6$; Jan. 18, $9^m \cdot 4$; Jan. 19, $9^m \cdot 3$.
Mar. 12	8 0	89	Not seen ...	Under 9·3	< 9·3	Probably under 10, but Moon near and flying clouds made observation very uncertain.
Apr. 2	7 40	70	*b* + 7; *d* − 3 ..	10·0 10·0	10·0	Twilight. *U* bluish-white. Twinkles rather peculiarly.
2	9 20	70 60	*d*?	10·3?	10·3?	I have some doubts as to the exact mag. of the star. At times it certainly looks no brighter than *d*. Colour bluish-white and a large disc not so sharply defined as that of *d*. It must be nearly one magnitude less than *b*.
3	8 40	60 70	*d* + 4; *f* - 5...	10·7 10·7	10·7	Bluish white with a large soft-edged disc. Wind N.E. and definition bad, but sky clear. Used full, and 5-inch apertures. *e* certainly less than 10·6—more like 11·0.
Oct. 24	11 10	89	Not seen ...	Under 13	< 13	*k* glimpsed at times. 6^h from meridian.
Dec. 29	7 10	70	*b* + 5? ...	9·8	9·8	6^h from meridian, and snow clouds coming up. A bright 10 mag. bluish-white in hue. The star *e* is very bright. Is it equal to *b*? Certainly brighter than *U*. But clouds make these observations very unsatisfactory and uncertain.
1871. Jan. 5	7 40	70	Not seen. Under $10\frac{3}{4}$	Under $10\frac{3}{4}$	< $10\frac{3}{4}$	*U* lost in haze and moonlight. *e* seen fairly at times and from comparison with *d* about 10·7 mag. Probably we may say that *U* is not brighter than 11 mag. (N.B.—Bad weather prevented my observing the star in the interval between Dec. 29 and Jan. 5.)
5	8 25	89	Not seen ...	Under 12	< 12	[Later same evening] *g* and *h* occasionally glimpsed feebly.
12	7 45	70 191	Feebly glimpsed at times with 19·?	14 ±	14 ±	*k* and *l* seen. $e = 10\frac{3}{4}$ mag. (perhaps this obs. refers *not* to *U* but to the faint star between it and *k*). (Note added 1871 Jan. 26.—G. K.)

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871. Feb. 8	h m 8 5	89	Not seen ...	Under 13·7	< 13·7	*k* and *l* seen.
18	8 50	70 89	Not seen ...	Under 13·7	< 13·7	*k* seen. *l* glimpsed at times.
23	7 0	153	Glimpsed at times?	Under 14	< 14	*l* seen well.
Mar. 1	7 55	156	Not seen ...	Under 13·3	< 13·3	*k* seen at times in moonlight and haze.
3	8 45	70 156	Not seen ...	Under 12·5	< 12·5	Moon bright and near. *g* and *h* well in view. *k* questionably glimpsed once or twice ? ?
7	8 40	156	Not seen ...	Under 13·7	< 13·7	*l* glimpsed at times. Strong wind from S.W.
13	9 30	156	Not seen ...	Under 13·7	< 13·7	*k* and *l* seen. (*U* observed by Mr. Baxendell this night of 13·7 mag. !)
15	?	70	Not seen ...	...	...	Cloudy. *b* and *c* only feebly visible at times.
16	9 45	70 156	Not seen? ...	Under 13·7	< 13·7	Either *U* or its comes, I believe the latter, feebly glimpsed at times. If so, not > 14·5 mag. *k* and *l* well seen. Carefully obsd. in consequence of note from Mr. Baxendell, who saw *U* 13·7 mag. on March 13 !
18	8 45	156	Feebly glimpsed	14·5?	14·5 ?	Both *U* and comes feebly glimpsed at times ? *k* and *l* seen, haze troublesome.
22	8 55	102 156	... ...	Not > 13·7	...	*k* well seen. *l* well seen at times. Qu. Is *U* feebly seen at times ? Vision unsteady. Sky not uniformly clear.
24	8 10	156	*l* + 2 + 1 ...	13·9 13·8	13·85	Clear. *k* and *l* well seen. *U* also distinctly seen and nearly equal to *l*. The small star between *U* and *k* also glimpsed. The light of *U* more unsteady than that of *l*.
26	8 45	156	*l* + 5? ...	14·2?	14·2?	Glimpsed at times, certainly, but not > 14. *k* and *l* *well* seen.
Apr. 1	8 15	156	Not seen ...	Under 13	< 13	*l* not seen. *k* glimpsed at times. Moon bright and rather near, and obs. rather interrupted by passing clouds.
4	10 30	156	Not seen ...	Under 13·3?	< 13·3?	Certainly under 13 mag. *k* seen at intervals. *l* glimpsed once or twice. Moon nearly full.
6	10 35	156	Not seen ...	Under 13·3	< 13·3	*k* seen at times. *l* feebly glimpsed once or twice. Field illuminated by strong moonlight.
10	10 45	156	Not seen ...	Under 13·7	< 13·7	*l* well seen at intervals. *k* pretty steadily seen.
Oct. 9	11 50	70 115	Not seen ...	Under 12	< 12	*f*, *g*, *h* seen. But 7ʰ from meridn. and obs. difficult; obs. not worthy of much confidence.
12	12 5	115	Not seen ...	Under 13	< 13	*k* glimpsed at times. *U certainly* under 12·5. *g* and *h* well seen.
23	11 30	115	Not seen ...	Under 12	< 12	*g* and *h* seen, but not steadily. *g* certainly > *h* by one or two tenths.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871. Nov. 18	h m 10 30	115	Not seen ...	Under 12·3	< 12·3	*k* glimpsed? Stars low and sky hazy.
Dec. 4	9 15	115	Not seen ...	Under 13	< 13	Under 13·3, I think I may say. *k* seen at times. Obs. difficult.
12	10 40	191	Glimpsed? ...	Under 13·7	< 13·7	Both *U* and comes, I believe, glimpsed at times. *l* pretty clearly seen. *U* not greater than 14 mag.?
20	10 10	115	Not seen ...	Under 13	< 13	*k* seen, but obs. much interrupted by clouds.
20	11 30	191	... ...	Under 13·7	< 13·7	*k* and *l* seen. Qu. *U* or comes feebly glimpsed at times?
1872. Jan. 6	7 45	191	Seen at times $=l$?	13·7?	13·7?	Stars rather low.
8	8 5	115 191	Glimpsed ...	Not > 13·7	> 13·7	*k* and *l* seen. *U* (and its comes?) glimpsed at intervals.
11	9 10	191	... ...	14 ±	14 ±	Glimpsed, but less than *l*.
14	8 50	191	Glimpsed? ...	Under 13·7	< 13·7	*l* fairly seen at times. *U* certainly not greater than 13·7.
Feb. 2	8 20	115 191	Not seen ...	Under 13·7?	< 13·7?	Certainly under 13·3, probably under 13·7; *k* well seen at times, *l* glimpsed. Hazy.
8	8 50	191	Seen at times	$14\frac{1}{2}$ est.	14·5 est.	*U* and comes both seen, some tenths less than *l*. *k* and *l* well seen.
14	7 40	70 115	Not seen ...	Under 13·3	< 13·3	*k* seen. Observed among clouds.
21	9 5	70 115	$b+10$; $=d$; $e-3$	10·3 10·3 10·3	10·3	White. Obs. not very easy in bright moonlight. Moon near.
23	8 10	70	$a+8+10$; $b+1+2$	9·4 9·6 9·4 9·5	9·5	Bright moonlight and haze. Only *a*, *b*, *c*, and *U* visible. The night of the 22nd was cloudy and no obs. possible. On the night of the 20th the stars in the neighbourhood were quite obliterated by the Moon, which was bright and near.
25	8 30	70 115	$a+10$; $b+3+4$; $d-7-6$	9·6 9·6 9·7 9·6 9·7	9·64	Bright moonlight and obs. interrupted by clouds. *U* $9\frac{1}{2}$ $9\frac{3}{4}$ est. Shines with a greyish white light and has not the hazy appearance I have sometimes noticed, but seems pretty sharply defined. No obs. possible on Feb. 24. Sky clouded.
25	10 45	70	$a+10$; $b+3+4$?; $d-7-6$?	9·6 9·6 9·7 9·6 9·7	9·64	A hasty obs. caught between driving clouds from N.N.E. The star *white* and *bright*, not *hazy*. I do not think the mag. is *less* than last night, but the obs. is a little uncertain.
27	8 30	70	$b+4$; $d-6$ ...	9·7 9·7	9·7	Clear. I think *U* is hardly so bright as last night. White, not hazy. Soon after taking this obs. clouds *grew* over the sky. Cold N.N.E. wind. Thermometer in obs. 36°.
28	8 45	70	$b+4$ (+3?) $d-6$	9·7 9·6? 9·7	9·7	Obs. caught between clouds. *U* not *less* than last night. Qu. a little brighter.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1872.	h m					
Mar. 4	7 5	70 115	$b+10$; $=d$; $f-9$	10·3 10·3 10·3	10·3	An extraordinary maximum. Star obsd. in clear intervals between low clouds driving over rapidly from S.E. It is about four-tenths brighter than *e*, which is, I think, barely so bright as 10ᵐ·6. Its hue is bluish white, a little *dull*, I think. Definition bad, but sky quite clear at times.
5	7 0	70	$d+2+3$; $f-7-6$	10·5 10·6 10·5 10·6	10·55	Twilight. Clear. *U* a tenth or so greater than *e* (*e* abt. 10·6 mag.).
5	10 20	70 89	$d+3$; $f-6$...	10·6 10·6	10·6	*U* bluish white? Seems to twinkle rather strongly occasionally, and to be rather dull and ill-defined, but this is perhaps due to atmosphere. Air still, but execrable definition. Wind S.E.
6	8 0	70 89 191	$=f$	11·2	11·2	A careful est. under different mag. powers. *U* grey white and not, I think, so sharply defined as *f*, but though brilliantly clear the definition is not good. *k*, *l*, and the minute speck between *U* and *k* well in view (this latter), a full third of distance from *U* to *k*, a little out of the line points more nearly to 11·2 mag. star south of *k*. *U* certainly not sharply defined. Wind S.E.
8	10 25	89 70	$h+7$; $k-3$...	13·0 13·0	13·0	Clouds coming up. Sky hazy and obs. difficult, the disc of *U* seen under averted vision seems rather large. Grey white in colour.
9	9 55	89 191	$=l$; $l-1$? ...	13·7 13·6?	13·65	Tolerably clear, but slight haze occasionally.
Apr. 10	9 10	70 156	(Glimpsed??)	...	Under 13·7	*l* seen.
13	10 15	70 156	Not seen ...	...	Under 13·3	Hazy and moonlight.
May 21	10 0	70	Not seen ...	...	$<9\frac{1}{2}$	Stars low, 6ʰ past meridian and field flooded with light. Only *b* and *c* seen. *U* certainly under $9\frac{1}{2}$ mag. Sky hazy and bright moonlight.
Oct. 22	11 30	115	Not seen ...	...	...	*a*, *b*, and *c* seen, but almost lost in haze and moonlight.
28	11 50	191	Glimpsed ...	13·7	13·7	Certainly seen at times. Not less than *l*. Rather hazy and at times *k* not at all well seen.
Nov. 11	10 50	115	Not seen ...	Under 12·3	$<12·3$	*g* and *h* well seen. *h* rather brighter than *g*? Obs. very difficult and unsatisfactory. Snow clouds (?) driving over from N.
12	9+?	191	Not seen ...	Under 12·3	$<12·3$	*g* and *h* seen. Moonlight and haze.
23	9 10	115	Not seen	Under 12	<12	*f*, *g*, and *h* well seen at times, but stars low, and haze and driving clouds make obs. almost impossible.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1872. Dec. 4	h m 9 0	115 191	Not seen ...	Under 13·3	< 13·3	*k* seen, *l not seen*, or only feebly suspected.
7	10 55	191	= *l*; *l* + 1 ...	13·7 13·8	13·75	Very well seen at times, and about equal to *l*. *l* not in constant view. I doubt whether I glimpse the small star between *U* and *k*. Moonlight.
9	9 0	115 191	Glimpsed at times?	Under $13\frac{1}{2}$	< $13\frac{1}{2}$	*k* glimpsed at times. Qu. is *U* glimpsed at times? Obs. *very* doubtful.
9	10 30	191	... ...	Under $13\frac{1}{2}$	< $13\frac{1}{2}$	*k* well seen. *l* and perhaps *U* feebly glimpsed at times. Moonlight and haze.
1873. Jan. 2	9 0	191	Feebly suspected at times	Under 13·7	< 13·7	*k* well seen. *l* pretty well seen at times.
21	6 15	89 191	Not seen ...	Under 13·3	< 13·3	Less than *k*, which is well seen. *l* glimpsed.
24	9 10	89 191	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* suspected.
28	6 50	89	Not seen ...	Under 13·5	< 13·5	Certainly under 13·3. *k* well seen. *l* glimpsed.
1876. Nov. 17	10 30	89 156	Glimpsed? ...	...	< 13·7	*k* seen. *l* at times. Possibly at times *U* glimpsed; if so, not > 13·7.
29	10 30	89	Not seen ...	Under $12\frac{1}{2}$	< 12·5	*g* and *h* well seen. *k* glimpsed doubtfully. Bright moonlight, haze and cloud.
Dec. 21	10 30	89	Not seen ...	Under 13·5	< 13·5	*k* seen. *l* glimpsed.
22	10 45	191	Feebly glimpsed?	14 ± ??	14 ±	*k* and *l* seen.
1877. Jan. 9	11 15	89	Not seen ...	Under $12\frac{1}{2}$	< 12·5	Obs. very difficult from cloud and haze. At times stars quite invisible, *k* feebly glimpsed at rare intervals. *g* bright, some tenths > *h*? = *f* + 5, *h* − 5; − ∴ 11·7 11·8
17	10 45	89 156	Glimpsed at times	14 ± ?	14 ±	*l* pretty well seen at times. *U* less than *l*. *g* abt. 5 > *h*. *U's* comes also glimpsed.
20	7 30	115	Not seen? glimpsed?	Under 13·5	< 13·5	*k* well seen. *l* glimpsed at times. Qu. *U* and comes feebly suspected at times?? 14 mag.??
23	8 0	115	Not seen ...	Under 13·3	< 13·3	*k* seen. Bad definition.
25	11 0	115 191	Not seen ...	Under 13·5	< 13·5	*k* pretty well seen. *l* glimpsed. Bright moonlight.
26	10 15	115	Not seen ...	Under 12	< 12	Stars almost lost in bright moonlight and haze. *g* = *f* + 6, *h* − 5 (= 11·8 11·8). *h* pretty clearly seen at times, *k* not seen.
30	8 0	115 191	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* glimpsed. Bright moonlight. *g* abt. $\frac{1}{2}$ mag. > *h*.
Feb. 16	8 25	191 115	Not seen? glimpsed?	Under 13·7	< 13·7	Glimpsed?? *k* and *l* seen. Clear but bad definition. *g* $\frac{1}{2}$ mag. > *h* = $\frac{1}{2}$ (*f* + *h*)?

U Geminorum—continued.

Date of Observation	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877. Feb. 16	h m 11 40	191	Clearly seen $=l+3$?	14·0	14·0	Distinctly seen. Rather less than *l*. Comes also glimpsed. (Later same evening as preceding.)
17	7 30	191	$l+3$? ...	14·0	14·0	Comes also glimpsed.
20	8 10	115 191	$k-0-2$ ...	13·3 13·1	13·2	Well seen, but definition very bad.
21	10 30	70	$b+5$; $d-5$...	9·8 9·8	9·8	Obs. caught in clear intervals between clouds from north. Sky very clear in the breaks. *U* bluish-white. $a+2>b=b>U$. $b-(a+2)=U-b$.
23	8 45	70	$a+13$; $b+6$; $d-4$	9·9 9·9 9·9	9·9	Moon bright and rather near. Observed in intervals between clouds, I think hardly so bright as on the 21st. Bluish-white.
25	10 0	70	$b+6$; $d-4$??	9·9 9·9	9·9	A hurried obs. between flying clouds. The star of sensibly the same mag. as on the 23rd.
26	9 0	70	$b+5+6$; $d-5-4$	9·8 9·9 9·8 9·9	9·85	Bright moonlight. About as much $>d$ as $<b$. White or bluish-white. Mag. unchanged?
27	9 0	70	$b+6$; $d-4$	9·9 9·9	9·9	Bluish-white and hazy; perhaps slightly less than last night.
28	7 0	70	$b+6$; $d-4$...	9·9 9·9	9·9	White or bluish-white. Much as last night. About 10 mag. est. Seems to scintillate rather more decidedly than neighbouring stars. Decreasing ??
Mar. 1	7 35	70	$a+13+14$; $b+6+7$; $d-4-3$; $e-7-6$	9·9 10·0 9·9 10·0 9·9 10·0 10·0 9·9	9·95	About 10 mag. bluish-white, scintillates rather strongly, much the same as last night, I think. *g* some tenths $>h$. *e* about 10·6 mag. *U at least* a mag. $>f$.
4	11 50	70 115	$=f$; $f-1$?	11·2 11·1	11·15	Observed in a clear interval between clouds. Bad definition. *U* greyish-white and *hazy* as compared with *f* and other stars. Disc seems large and ill-defined.
5	10 30	115	$f+5$; $h-6$...	11·7 11·7	11·7	Observed with some little difficulty in a capricious sky. Cloud and haze troublesome. *U* about equal to *g*, which is some tenths (half a mag.?) brighter than *h*.
5	10 55	191	$f+4+5$; $h-7-6$	11·6 11·7 11·6 11·7	11·65	Obs. hardly satisfactory. Haze very troublesome.
5	11 40	115	$f+6$; $h-5$...	11·8 11·8	11·8	A fair obs. Sky pretty clear.
6	9 0	115	$f+11$; $=h$; $k-10$	12·3 12·3 12·3	12·3	12½ mag. est. Tolerably clear, but bad definition.
6	10 30	191	$h+2$; $k-8$...	12·5 12·5	12·5	Obs. hardly satisfactory. Sky fairly clear, but definition unsteady and poor.
8	8 0	191	$k+4$; $l-0-1$	13·7 13·7 13·6	13·7	Clear; fairly seen. *g* some tenths brighter than *h*.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877.	h m					
Mar. 30	8 45	115	Not seen ...	Under 13·3	< 13·3	*k* seen, *l* glimpsed? hazy. *g* a bright 12 mag., some tenths brighter than *h*.
May 4	9 10	115 191	Not seen ...	Under 13·5	< 13·5	*k* well seen, *l* glimpsed. *g* several tenths less than *h*.
Sept. 28	12 30	70 115	Not seen ...	Under $9\frac{1}{2}$	< $9\frac{1}{2}$	*b* and *c* well seen, *d* not seen, stars low. Moon bright, $6\frac{3}{4}$ hrs. from meridian.
Oct. 4	12 15	115	Not seen ...	Under 13·3	< 13·3	*k* seen pretty well at times, *l* occasionally glimpsed?? $6\frac{1}{2}$ hrs. from meridian.
5	12 55	115	Not seen ...	Under 13·3	< 13·3	*k* pretty well seen. *l* glimpsed. 6ʰ from meridian.
15	12 15	115	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* glimpsed ??
27	11 30	70	Not seen ...	...	...	*a*, *b*, *c*, and *d* seen. Field flooded with moonlight.
Nov. 1	11 50	115	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* glimpsed.
3	11 45	115 191	... ...	Under 13·5	< 13·5	*k* and *l* seen. *U* or comes glimpsed. Not > 13·7.
14	11 25	115 191	... ...	Under 13·3	< 13·3	*k* seen well. *U* glimpsed?? *l* not *certainly* seen.
16	11 15	115	Not seen ...	Under 13·3	< 13·3	*k* glimpsed.
19	11 50	89	Not seen ...	Under 12·5	< 12·5	*g* and *h* well seen. *k* not seen. Field flooded with moonlight.
Dec. 6	12 0	191	... ...	$14\frac{1}{4}$?	14·25?	Both *U* and comes glimpsed at times. Faint 14 mag. Some tenths less than *l*, which was well seen. *k* very conspicuous.
10	11 15	70 115	Not seen ...	Under 13·3	< 13·3	*k* seen. Clouds coming over. Obs. doubtful.
12	10 15	191	= *l*	13·7	13·7	*g* rather brighter than *h* certainly.
13	8 45	89 191	Glimpsed? ...	Not > 13·7	Not > 13·7	*k* well seen. *l* and *U* perhaps glimpsed. *U* not > *l*.
18	10 40	70	*a* + 12; *b* + 5; *d* − 5	9·8 9·8 9·8	9·8	White. Moonlight and haze rather troublesome.
	11 0	70 115	... ...	9·8 9·8	9·8	Bluish-white and sharply defined. About as much fainter than *b* (9·3) as it is brighter than *d* (10·3). *k* feebly glimpsed at times. *l* quite invisible. *g* a tenth or two brighter than *h*. Moonlight, and ground mist and haze troublesome. A bright 10 mag. est.
23	12 50	70	*a* + 6; *e* + 3; *f* − 3	10·9 10·9 10·9	10·9	Caught bet. clouds. The est. perhaps a little doubtful. Moonlight. *U* certainly considerably fainter than *d* and rather brighter than *f*.
24	9 10	70 115	*f* + 3; *h* − 8 ...	11·5 11·5	11·5	*g* very much brighter than *h*. Almost equal to *U*.
26	9 5	115 191	*k* + 2 + 3; *l* − 1	13·5 13·6 13·6	13·6	Obs. a little difficult.
	10 20	191	*k* + 2; *l* − 2...	13·5 13·5	13·5	Bad definition, but at times pretty clear.
27	8 10	191	*k* + 3; *l* − 1 ...	13·6 13·6	13·6	*g* = *h* − 3. Clear and cold.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1878. Jan. 7	h m 10 15	115	$=l$? $l+$? ...	13·7 13·7	13·7	Glimpsed at times, as also l.
	10 20	191	$=l$	13·7	13·7	At times fairly seen, and the small star between U and k feebly glimpsed.
Feb. 18	11 55	115	Not seen ...	Under 13	< 13	Bright moonlight. k glimpsed. h slightly brighter than g.
Mar. 12	11 20	115	Not seen ...	Under 12·3	< 12·3	g a few tenths less than h. Moonlight and hazy cloud. Obs. very unsatisfactory.
15	8 55	115	Not seen ...	Under 13	< 13	k feebly glimpsed at times. Moon bright and rather near.
16	8 50	89 191	... ...	14 14·5	14·25	Both U and comes (?) glimpsed at times pretty distinctly. l well seen. k very conspicuous. Clear at times, but def. very poor.
Apr. 3	8 35	89 191	Clearly visible at times	14¼ 14½?	14·38	k and l well seen. U and comes both distinctly seen at times. U rather more easily of the two? g and h about equal.
22	11 40	70	$a+7$; $=b$; $d-10$	9·3 9·3 9·3	9·3	9¼ est. White with bluish tinge. Rather large disc? 6ʰ past meridn.; fairly clear.
24	10 20	70	$=b$; $d-10$...	9·3 9·3	9·3	White (large disc?). Obs. a little doubtful. Among clouds. Poor definition.
25	10 15	70	$a+8$; $b+1$; $d-9$	9·4 9·4 9·4	9·4	White, or bluish-white. Clear, but definition poor. Obsd. with full aperture and with 4½ inches.
26	10 40	70	$a+9$; $b+2$; $d-8$	9·5 9·5 9·5	9·5	Clear. Poor definition. U white.
27	10 20	70	$a+9$; $b+2$; $d-8$	9·5 9·5 9·5	9·5	Clear. I think no change from last night. h two or three tenths brighter than g. (Better worded, perhaps, g two or three tenths less than h.)
May 1	10 30	70 115	$f+5$; $h-6$...	11·7 11·7	11·7	Obs. a little doubtful, perhaps. Thin clouds about. U a bright 12 mag. est.
Oct. 14	12 20	89 115 191	Not seen ...	Under 12½	< 12·5	Obs. difficult in moonlight, and stars 6ʰ from meridn. g and h well seen. g rather the brighter of the two. k occasionally very feebly glimpsed.
Nov. 2	11 55	115 191	Not seen ...	Under 13·3	< 13·3	k glimpsed. g some tenths brighter than h. Haze at times.
16	10 40	115	Not seen ...	Under 13?	< 13?	k occasionally feebly glimpsed. g several tenths brighter than h. $=f+7$; $h-4$? 11·9 mag.? Moon rising and heavy clouds coming over.
1879. Jan. 15	9 0	70	$a+13$; $b+6$; $d-4$	9·9 9·9 9·9	9·9	Pale bluish-white. Large disc, rather ill-defined. Clear sky.
	10 0	70	$b+6+7$; $d-4-3$	9·9 10·0 9·9 10·0	9·95	Still and clear. With power 191 U pretty well-defined. Disc a little *soft* perhaps. *White*, or bluish-white. g bright; some half mag. or so brighter than h.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1879. Jan. 16	h m 8 45	70	$a+14$; $b+7$; $d-3$	10·0 10·0 10·0	10·0	Bluish-white. Much as last night; hardly so bright? Wind N.E. and def. poor. Clouds about. Disc a little large, perhaps, but this may be due to atmosphere. *b* and *c* not very sharp. *g* some few tenths brighter than *h*.
	9 0	...	$b+6$; $d-4$	9·9 9·9	9·9	Qu. *U* rather brighter by a tenth or two?
19	8 0	70	$d+4$; $e+0+1$; $f-5$	10·7 10·6 10·7 10·7	10·7	Fair obs. *g* considerably $>h=f+2$? About 11+mag. Clear. Cold, east wind. *U* rather large disc?? If $d=10·3$ I think 10·6 is fair est. for *e*. Obs. impossible on 17th or 18th on account of clouds.
22	10 0	191	$k+1$; $l-3$...	13·4 13·4	13·4	Obs. rather difficult. Cold wind and def. uncertain. *g* some few tenths $>h$. The small star bet. *U* and *k* glimpsed at times? Very doubtful. Qu. is $b>c$ (both stars as one)? I doubt it.
Mar. 13	8 30	70 115	Not seen ...	Under 13·5	<13·5	*k* well seen. *l* at times well seen. Either *U* or comes suspected at times.
29	10 0	191	Glimpsed at times? Barely $=l$?	14±?	14?	*k* seen. *l* fairly seen at times. *U* glimpsed? Hardly so bright as *l*. *h* rather brighter than *g*. Moonlight, and clouds troublesome at times.
Apr. 10	10 15	115	... ...	Under 13·3	<13·3	Not seen. *k* well seen. *l* glimpsed.
May 2	10 20	70 89	Not seen ...	Under 12·3	<12·3	*g* and *h* seen. Field flooded with moonlight. Very bad definition.
Oct. 6	13 25	115	Not seen ...	Under 12·3	<12·3	*g* and *h* seen, but obs. very difficult in moonlight and haze.
15	12 10	115	Not seen ...	Under 13·3	<13·3	*k* pretty well seen at times. *g* rather brighter than *h*? Obs. not very satisfactory. Stars 6 hrs. from meridian, and vision not very good.
20	11 25	89	Not seen ...	Under $12\frac{1}{2}$	<12·5	*g* and *h* well seen. *k* not seen.
25	11 25	115	$=d$; $e-3$ (about as much $>f$ as f is $>h$)	10·3 10·3 (10·1)	10·3	Bluish white. Not sharply defined. $10\frac{1}{4}$ est.
26	11 40	115 160	$d+3$; $e-0-1$; $f-6$	10·6 10·6 10·5 10·6	10·6	Obs. difficult in moonlight and haze. *U* white and ill-defined, *g* slightly $>h$. *k* quite invisible. Light clouds about.
Nov. 2	11 55	191	Not seen ...	Under 13?	<13?	*g* and *h* well seen. *g* slightly $>h$? *k* not seen. *U* not seen certainly. Qu. at times suspiciously glimpsed??? Very doubtful indeed. Field bright with moonlight and haze. *U* can certainly not be above 13 mag. No chance of observing since this day last week, a week of cloudy skies.
2	12 5	...	...	...	...	I fancy I glimpse *k* at times, but do not see *U*. Def. bad, cold, wind north.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1879. Nov. 5	h m 11 30	...	...	...	...	Field of *U Gem.* lost in bright moonlight, only *b* and *c* visible.
12	10 20	115 191	Not seen certainly ...	Under 13·3	< 13·3	*k* well seen. Qu. *l*? and *U*??? feebly suspected at times? very doubtful.
18	10 40	150	Not seen ...	Under 13·5	< 13·5	*k* well seen. *l* glimpsed at times.
Dec. 10	11 10	191	... ...	...	...	*U* or comes glimpsed. *k* and *l* well seen. *g* a tenth or two > *h* with 115. 3 or 4 > *h*.
1880. Jan. 2	10 10	115 191	$k+3$; $l-1$...	13·6 13·6	13·6	Very clearly visible at times. Slightly brighter than *l*.
3	9 0	115 191	$l+0+2$? ...	13·7 13·9	13·8	At times almost equal to *l*. The comes bet. *U* and *k* glimpsed at times.
12	11 35	115	$=l$	13·7	13·7	Both *U* and *l* well seen at times. About equal in mag.
19	10 20	115	$l+1$? ...	13·8?	13·8?	Glimpsed certainly at times, barely equal *l*. *g* some few tenths greater than *h*.
20	10 5	191	$l+1$? ...	13·8?	13·8?	*U* and *l* both glimpsed at times. *U* barely so bright as *l*? *g* some tenths > *h*.
26	9 0	70 89 115	$b+6$; $d-5$...	9·8 9·8	9·8	$9\frac{3}{4}$ est. Moon bright and near. *U* white and shining brightly.
	9 40	70 115	$b+4+5$; $d-6$	9·6 9·7 9·9	9·7	*U* shines with a steady white light. Obs. very difficult in bright moonlight.
27	11 45 11 50	70	$b+2+3$; $d-8$	9·4 9·5 9·5	9·5	*U* bright and white. About equal to brighter component of *c*. *b* rather ruddy orange tint. Obs. difficult in bright moonlight and haze. At 11·55 clouds come over. I think *U* must be about 9·5. 9·6 mag. A very white frost. Is *U* brighter than last night? I almost fancy it is. But comparisons under circumstances of field flooded with moonlight very unsatisfactory and difficult. *e* and *f* visible.
28	10 40 10 55	70 115	$b+3$; $d-7$...	9·5 9·6	9·55	*U* white, light a little unsteady? Equal or barely equal *A* of *c*? About as bright as last night or barely so? Moonlight and haze troublesome, but field fairly seen. *h* a glimpse object. *g* bright $=f+4+3$, $h-7$, *A* of $c=b+2$, *b* orange tint, *A* of *c* white, as *U*. $U=\frac{1}{2}(a+d)$, nearer *d*. $10^{h}\ 55^{m}$ haze coming over.
29	8 35 9 0	70	$b+1+2$; $=A$ of *c*; $a+7+8$; $d-9$	9·3 9·4 9·3 9·4 9·3 9·4 9·4	9·35	*b* gauged 9·2. *U* gauged 9·3 9·4. *A* of *c* 9·3 9·4. *a* gauged 8·6. *d* 10·3 10·4. *U* a little hazy? bluish white. *b* orange tint. *c* as one star about equal *b*. *c* white or bluish white. $g=f+4$; $h-7$. Failed to make anything of *U* with McClean spectroscope. With Browning's eye-piece spectroscope only a continuous spectrum, rather feeble. *U* not fainter than last night, once a faint suspicion of a bright knot on spectrum with e.p. spectroscope, but could not confirm it. (30/1/80 G. K.)

U Geminorum—continued.

Date of Observation	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1880. Jan. 30	h m 6 25	70	$b+2$; $a+8$; $d-9$	9·4 9·4 9·4	9·4	Much of same mag. as last night, barely so bright? 9·5 gauged.
	8 30	70	$a+8$; $b+2$; $d-9$	9·4 9·4 9·4	9·4	Gauged mags. of comparison stars *a* 8·5 8·6; *b* 9·2 9·3; *c* 9·1 as one star; *d* 10·3 10·4; *e* 10·6; *U* 9·4 9·5; *U* bluish white, disc a little large. Qu. I do not notice the orange tint of *b* so decidedly to-night. *g* several tenths $>h$.
31	6 50 7 10	70	$a+9$; $b+3$; $d-8$	9·5 9·5 9·5	9·5	Bluish white. Barely so bright as last evening? Gauged 9·5. Light a little unsteady? With 115 colour of *U* decidedly bluish white. $g=f+3$; $h-7-8$. *b* yellow and about equal *A* of *c*. *c* as one star, brighter by a tenth or so.
Feb. 1	8 40	70	$b+2+1$; $=A$ of c?; $a+8$; $d-9$	9·4 9·3 9·4 9·4	9·4	Bluish white. Unchanged? Quite as bright as last night certainly. *U* gauged 9·4. *b* gauged 9·2. *c* as one star 9·1. *a* gauged 8·6. *g* still bright. $f+2+3$. $h-7-8$. *d* 10·3. *e* 10·6 gauged. *U* not at all indistinct or hazy. Quite sharp. Certainly *not less* than last night.
3	11 20	70 60 115	$a+9$; $b+2+3$; $d-9$	9·5 9·4 9·5 9·4	9·45 9·4	Barely so bright as on the 1st? But gauged 9·4. *b* 9·2 with 60, and *c* hidden by bar $U=b+2$ bluish white. A brilliant sky after a misty foggy day. $g=f+4$; $h-7$. (N.B.—Feb. 2. Cloudy and hazy, no obs. possible.)
4	9 55	70	$b+6$; $d-5$; $a+12$	9·8 9·8 9·8	9·8	Decidedly on the wane. Gauged 9·7 mag. Bluish white.
	11 0	70	$b+7$; $d-4$...	9·9 9·9	9·9	*U* gauged 9·8 9·9. (Cloudy skies bet. Feb. 4 and Feb. 8.)
8	8 50	70 115 89 191	$f+11$; $=h$; $k-10$	12·3 12·3 12·3	12·3	Clear sky. *l* well seen and small ✱ bet. *U* and *k* glimpsed fairly. *U* gauged about 12·3. *U* "looms large," and at times almost looks $>h$. Full aperture and $4\frac{1}{2}$ inches. $g=f+4$; $h-7$.
11	10 5	115	$k+3$; $l-1$...	13·6 13·6	13·6	*k* well and steadily seen. *U* and *l* seen at times. $g=f+4+5$; $h-6$.
Mar. 13	9 0	115	Certainly glimpsed	14±	14±	*k* and *l* well seen. $g\ 2>h$.
15	9 0	115	Glimpsed? ...	14?	14?	*k* and *l* well seen. *U* glimpsed at times? Not brighter than 14^m? *g* about $=h$.
25	8 0	115	Not seen ...	Under 13·3	<13·3	A hazy sky. *k* well seen. *l* not glimpsed at all. *g* 2 or 3 $>h$.
29	8 50	115	Glimpsed ...	14?	14?	*k* and *l* well seen. Less than *l*; $g=h$.
Apr. 1	9 0	115	Glimpsed ...	14 14·2 est.	14·1 est.	*k* and *l* very clearly seen. *U* very decidedly less than *l*. Small star between *U* and *k* also glimpsed. $g=h-0-1$.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1880.	h m					
Apr. 5	10 5	115	$l+2+3$ ...	13·9 14·0	13·95	Well seen at times. *k* and *l* well seen. *U* at times seems to "sparkle up," but probably this is atmospherical. *g* a tenth or two brighter than *h*.
6	10 30	115	Glimpsed at times	14 + ?	14 + ?	Several tenths less than *l*. *k* and *l* seen pretty well. *g* a tenth or two > *h*.
12	10 25	115 89	$=l$	13·7	13·7	Both *l* and *U* seen at intervals and about equal. *k* well seen at times. *g* barely so bright as *h*? Cloud and haze a little troublesome.
15	10 45	115	... ...	Under 13·7 ?	< 13·7 ?	Not seen with certainty. *k* well seen. *l* glimpsed at intervals. Qu. *U* glimpsed? Very doubtful.
20	8 55	115 191	... ...	...	...	Moonlight troublesome. *k* well seen. Qu. *l* and *U* glimpsed?? Doubtful.
27	10 30??	...	$l+3$? ...	14	14·0	Glimpsed at times clearly. Barely equal *l*. = 14, say. *k* and *l* seen pretty well. $g=h$?
30	9 35	115	Glimpsed? ...	...	...	*k* and *l* well seen. Qu. *U* glimpsed once or twice? *g* slightly fainter than *h*.
May 1	9 5	156	Glimpsed ...	14 ±	14 ±	*k* and *l* pretty well seen.
	10 0	115	... ...	...	...	*k* and *l* pretty steadily seen. *U* perhaps glimpsed.
8	10 0	115	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* once or twice glimpsed? *g* = or slightly > *h*?
12	10 0	115	Not seen ...	Under 13	< 13	Not seen; certainly under 13. *k* feebly seen at times. Stars low, definition bad. Cloud and haze troublesome.
17	9 50	115 191	Not seen ...	Under 12·5	< 12·5	*g* and *h* seen. *k* occasionally glimpsed. Moonlight and haze troublesome.
28	10 0	115	Not seen ...	...	...	Field flooded with twilight. *f*, and star south of *k* seen. *g* and *h* suspected at times. *U* certainly not brighter than 11·2 mag.
Oct. 11	11 0	70	Not seen ...	Under 10·3	< 10·3	*b* and *c* well seen, and the group about *d*. None of the stars about *U* seen. 7½ hrs. from meridian.
23	13 30	115	Not seen ...	Under 12½	< 12½	*g* and *h* seen. *k* *not* seen. Among clouds, and Moon bright.
Nov. 2	13 25	191	Occasionally glimpsed?	...	...	*k* seen. *l* and *U* occasionally glimpsed? *g* slightly brighter than *h*.
19	10 25	70	Not seen ...	Under 10·3	< 10·3	Field flooded with moonlight. *a*, *b*, *c*, and *d* seen only. Hazy.
25	10 25	115 191	... ...	...	13 7 ?	*k* well seen. *l* and *U* glimpsed at times. About equal?? *g* several tenths > *h*. Bad definition and obs. difficult.
Dec. 2	11 5	115	... ...	...	13·7 ?	*k* well seen. *l* and *U* glimpsed at times.
24	7 20	115	$=h$; $h-1$?...	12·3 12·2	12·25	Low, and cloud troublesome. *U* "looms large" about 12¼ mag. est. Obs. a little doubtful as to exact mag.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1880. Dec. 24	h m 8 50	115	$h-1-2$; $k-11-12$	12·2 12·1 12·2 12·1	12·15	Gauged 12·2, 12·1, h 12·3, g 12·0, 11 9. U looks rather large for its mag. N.B. J. Baxendell, in letter dated Dec. 25, 1880, writes thus: "Last night at 9^h 20^m U Gem. was about 12·0 mag., ruddy and hazy-looking."
25	11 15	89 191	$k+1$; $l-3$...	13·4 13·4	13·4	13·5 est. Large for its mag. Has a hazy look. Clear; a white frost. It is thus clear that U passed a maximum some few days ago.
30	10 30	115	Not seen ...	Under $13\frac{1}{2}$	< 13·5	k seen. l not seen. g 5 > h.
1881. Jan. 3	9 35	115	Not seen ...	Under 13·7	< 13·7	k and l seen. g 5 > h.
Feb. 15	8 45	70 115	Not seen ...	Under 13·3	< 13·3	k well seen. l not seen. $g=\frac{1}{2}(f+h)$. Half a mag or so > h.
28	8 25	70 115	Not seen ...	Under 13·3	< 13·3	k well seen. l not seen, or perhaps glimpsed at times. g about $\frac{1}{2}$ mag. > h.
Mar. 15	9 0	115	Not seen ...	Under 12·3	< 12·3	g and h both seen. g 5 or 7 tenths > h.
19	8 30	191	$l+3$... ...	14·0	14·0	Well seen, as also comes between U and k. $g=f+7$; $h-4$.
21	8 10	115 191	... ...	14 ± ?	14 ± ?	Not so bright as l. U and comes both seen. U rather the brighter? Sky clear and cold air. Snow showers this afternoon, leaving snow on ground.
22	8 35	115	... ...	14	14	A few tenths fainter than l. k and l well seen. g 3 or 4 tenths > h.
25	8 40	115	13·7 14 ...	13·7 14·0	13·85	At times seemingly as bright as l, and well seen.
26	8 25	115	... ...	14 ±	14 ±	Glimpsed. A few tenths less than l.
29	11 12	115	$l+3$? ...	14·0?	14·0?	Glimpsed. Barely so bright as l, which was well in view at times. U abt. 14 mag. g barely so bright at h? 12·4, 12·5 mag.? A cloudy sky clearing off. Cold N.N.E. wind.
30	9 45	115	Glimpsed 14?	14?	14?	Glimpsed in clear intervals bet. clouds. k and l well seen. g not less than h? Wind N.E., cold.
30	10 15	191	$l+4$ ...	14·1	14·1	Well seen at times, as also comes bet. it and k. g rather > h.
Apr. 2	10 10	70	$b+0+2$; $d-8-10$	9·3 9·5 9·3 9·5	9·4	Obs. made with difficulty in clear intervals bet. driving clouds. A very high wind from E.N.E. U bluish-white, disc rather large? Mr. Baxendell writes under date Apr. 2, 1881: "At 8.50 last night our old friend U Gem. was about 12·1 mag. Three hours later it had increased fully *one* mag."

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881.	h m					
Apr. 3	8 20	60 70	$=b$; $a+7$; $d-10$	9·3 9·3 9·3	9·3	Bluish-white. Disc not sharp. A hazy look about the star. With 60 had bar in eyepiece and hid c when comparing U with b. g a few tenths $>h$.
4	8 0	70	$=b$; $a+7$; $d-10$	9·3 9·3 9·3	9·3	Gauged in finder 9·3, 9·4. White. A cold wind, high from E.N.E.
6	10 5	70	$b+2$; $\frac{1}{2}(a+d)$	9·5 9·45	9·5	Hardly so bright as b? But obs. very doubtful. Moon rather near and clouds driving over from N.E. A hazy look abt. U compared with b.
7	8 35	60	$b+1$; $\frac{1}{2}(a+d)$	9·4 9·45	9·4	White or bluish-white. Not so *sharp* as b. Moon abt. first quarter, bright and near. Gauged 9·5.
9	8 50	70 115 60	$b+4$; $d-6$...	9·7 9·7	9·7	White. Gauged 9·7. Moonlight. I have great difficulty in satisfying myself as to the mag. of U. Certainly *less* than b. Moonlight and haze troublesome. g not $>h$? b ruddy orange. U with 115 bluish-white, not so *sharp* as b.
13	9 50	70 115 191	$f+2$; $h-9$...	11·4 11·4	11·4	Obs. very difficult in bright moonlight and haze. $g=h-4$?
15	9 50	115	$k+2$ ...	13·5	13·5	Pretty well seen. Hazy. Not so bright as k. l *not* seen.
26	9 5	115	Glimpsed ...	...	...	Glimpsed? Doubtful, very. l seen.
Oct. 2	14 15	115	Not seen ...	...	Under 13·3	k well seen. l glimpsed. U or comes glimpsed???
17	13 15	115	Not seen ...	...	Under 13·5	k well seen. l at times.
Nov. 15	11 2	...	Glimpsed? ...	...	14? ±	l seen at times. U glimpsed?
17	9 45	115	Not seen ...	Under $12\frac{1}{2}$	$<12·5$	k glimpsed at times?
19	9 50	115	Not seen ...	Under 13·3	$<13·3$	k seen. g 3 or 4 tenths $>h$. l not seen.
23	10 10	191	... ...	13·7 14	13·85 ±	Certainly seen. Nearly, if not quite, equal l.
28	10 20	115 191	Feebly glimpsed	Under 13·5	$<13·5$	k seen. l glimpsed. g several tenths $>h$.
29	11 27	115	Not seen ...	Under 12·5	$<12·5$	g and h well seen. k glimpsed perhaps. A hazy sky.
Dec. 3	9 50	...	Not seen ...	Under $11\frac{1}{2}$?	$<11\frac{1}{2}$?	Moonlight and clouds so troublesome that obsn. is almost impossible. U cannot, however, I think, be brighter than 11·12 mag. d, e, f seen. g and h glimpsed??
5	10 10	70?	... ...	Under $9\frac{1}{2}$	$<9·5$	Field flooded with moonlight and haze. a b c seen. U certainly less than $9\frac{1}{2}$ mag.
13	8 45	115	Glimpsed at times?	Under 13·5	$<13·5$	k well seen. l glimpsed. Qu. U glimpsed at times? g several tenths $>h$.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881. Dec. 21	h m 10 13	115	Glimpsed ...	14 ±	14 ±	*k* and *l* seen. *U* certainly glimpsed at times.
23	8 55	191	Glimpsed ...	14 ±	14 ±	*k* well seen. *l* pretty well. *U* and (*U's* comes?) glimpsed. *g* some few tenths > *h*.
29	8 45	115 191	Not seen ...	Under 13·3	< 13·3	*k* well seen. *l* not seen. Moonlight. *g* several tenths > *h*.
1882. Jan. 6	8 15	115 191	Not seen ...	Under 13·3	< 13·3?	*k* feebly glimpsed. Moonlight, haze and cloud. Obs. very unsatisfactory.
7	8 25	191	Glimpsed ...	...	...	*k* well seen. *l* glimpsed. *U* glimpsed? Doubtful. Moon getting up.
9	9 55	115 191	At times well seen	13·9 14	13·95	Barely so bright as *l*, wh. well seen. Comes between *U* and *k* glimpsed? Clear sky. *g* rather brighter than *h*.
21	7 25	115	Not seen ...	Under 12·3	< 12·3	*g* and *h* seen. *g* at least ½ mag > *h*. Haze and bad definition. *k* not seen.
21	8 30	115	Not seen ...	Under 13·5	< 13·5	*k* well seen at times. *l* suspected? Haze troublesome. *g* ¾ mag. > *h*.
24	9 5	115	Not seen ...	Under 13·3	< 13·3	*k* seen. *l not* seen.
	9 55	...	Glimpsed ...	14 ±	14 ±	*k* well seen. *l* glimpsed. Hazy sky; white frost.
Feb. 11	9 50	115	... ...	14 est.	14 est.	*k* and *l* well seen. *U* seen distinctly at times.
15	9 0	115	... ...	14·0 ±	14·0 ±	Clearly seen at times. *k* and *l* conspicuous.
17	7 3	115	... ...	14 ±	14 ±	*k* and *l* well seen. *U* well seen at times.
20	8 38	115 156	= *l*	13·7	13·7	*k* and *l* well seen. Small speck between *U* and *k* glimpsed. *U flashes out* bright at times? Real or apparent only?
Mar. 1	7 35	70	*b* + 4 + 5; *d* − 6	9·7 9·8 9·7	9·7	9·7. Among clouds. Moon bright and rather near. Disc (of *U*) rather large and ill defined? Obsn. hurried and a little uncertain. Clouds came rapidly over. A gale blowing. Up to midnight no further obs. possible. (N.B.—Persistently clouded skies since Feb. 20.)
2	10 50	70 115	*b* + 6; *d* − 4...	9·9 9·9	9·9	*U* not so bright as last night, I think. About 10 mag.? Light rather unsteady, colour *white* or *bluish-white*. Obsd. with full aperture and 3in·7. Moonlight troublesome. *b* ruddy. *c* as *one star* rather > *b*, I think. *g* several tenths > *h*.
3	7 20	70	*b* + 8; *d* − 2...	10·1 10·1	10·1	*U* fainter than last night; bluish white. Moonlight bright. Sky rather hazy, clouds coming over. Obsd. with full aperture and one of 4 inches.
	9 50	70	*b* + 9; *d* − 1; *c* − 4	10·2 10·2 10·2	10·2	Obsd. with full aperture, 3in·7 and 2in·0.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1882.	h m					
Mar. 4	7 35	70	$d+2$; $e-1$...	10·5 1·05	10·5	Obs. a little doubtful. Moonlight, and light clouds about.
6	8 55	115	$f+4$; $h-7$...	11·6 11·6	11·6	g nearly as bright as U. 11·7, 11·8 mag. Sky hazy. (Obs. by Mr. Baxendell in letter dated 1882 March 8: "1882 March 6, 8^h 15^m $f5>U8>h$, $U4>g$.·.$U=11·6$ mag.")
13	8 50	70 115	Glimpsed ...	13·7??	13·7??	k well seen. l glimpsed. Sky hazy. g some 5 tenths brighter than h.
15	9 0	115 191	$=l$	13·7	13·7	A clear sky. Star between U and k glimpsed. $g4>h$.
17	8 40	115	Glimpsed; $l+3$?	14 ±	14 ±	l well seen, and certainly several tenths $>U$, which is decidedly seen at times. $g=h-4$?
Apr. 4	8 40	115	Glimpsed ...	14 ±	14 ±	k and l well seen. U some few tenths $<l$. g 3 or $4>h$.
6	8 45	115 191	$l+3?+5?$ well seen at times	14·0 14·2	14·1	l well seen. Star speck between U and k glimpsed at times. $g=h-3-4$.
8	8 50	115	... ...	...	$14\frac{1}{2}$ est.	U and comes both glimpsed. l well seen.
20	8 55	115	Glimpsed ...	...	$14\frac{1}{2}$?	U and comes both glimpsed at times. k and l well seen. g some 6 or 7 tenths $>h$.
22	9 5	115	Glimpsed ...	...	14·5	k and l seen.
May 11	11 20	70	Not seen ...	Under $12\frac{1}{2}$?	< 12·5?	g and h seen. Doubtful observation, very.
15	10 35	115	Not seen? ...	Under 13·3?	< 13·3?	k seen. g several tenths $>h$. l not seen. Qu. U at times feebly glimpsed? Stars low and among haze.
16	10 30	70	Not seen ...	Under 12	< 12	Obs. caught with difficulty between clouds, and therefore doubtful. g and h seen; g well, h doubtfully. g some tenths greater than h.
18	10 5	115	Not seen ...	Under $12\frac{1}{2}$	< $12\frac{1}{2}$	Hazy and obs. difficult. g several tenths $>h$. k glimpsed at times?
20	9 50	115	Not seen ...	Under 12	< 12	Hazy and definition execrable, with an east wind. g and h seen. g several tenths $>h$.
27	10 15	70 115	$c+7$; $d-4$...	9·9 9·9	9·9	Far from meridian. Moonlight. Observation very doubtful, but no doubt that U was observed. White disc ill-defined.
28	10 5	60 70 115	$c+7+8$; $d-3-4$	9·9 10·0 9·0 10·0	9·95	10·0 est. Observation very difficult in light sky. Moonlight and twilight. (For certainty of identification U follows* b 1^m 18^s, 10′ north. U 20′ north of a which it follows by some 5^s or 6^s.) f, (h?), g and star above (south of) k visible.

* A mistake in entry? Should be precedes?

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1882. Oct. 24	h m 11 28	115 156	Not seen ...	Under 12 3	Under 12·3	*f*, *g*, and *h* seen. *g* a few tenths brighter than *h*. *k* not seen, very difficult observation. Moonlight and haze, and stars far from meridian.
25	11 2	115	Not seen ...	Under 12?	< 12?	Under 12? *g* and *h* glimpsed. Hazy.
Nov. 9	10 15	115	Glimpsed at times?	Under 13½	< 13·5	*k* well seen. *l* and *U* glimpsed at times?
17	10 0	115	$f+4$; $h-7$...	11·6 11·6	11·6	*k* not seen. Sky hazy and obs. rather difficult. $g>h$.
	11 0	156	$f+5$; $h-6$; $=g$?	11·7 11·7 11·7	11·7	$g=f+5$? *U* ill-defined. Obs. difficult. Result doubtful.
19	12 55	110	$k+2+3$; $l-2-1$	13·5 13·6 13·5 13·6	13·55	A high wind. *U* well seen, also *k* and *l*. *U* appears to have passed a maximum before the 17th. Certainly less than *k* and not much brighter than *l*. (Sunday night).
Dec. 19	9 35	110	Not seen ...	Under 13	< 13	*k* glimpsed. Hazy.
1883. Jan. 5	8 5	110 191	$l+0+2$? ...	13·7 13·9	13·8	*k* well seen. *l* and *U* seen well at times. *U* barely $=l$? *g* and *h* about equal.
26	7 30	70	$b+5$; $d-5$...	9·8 9·8	9·8	9·8 gauged. Bluish white.
	7 55	...	... ...	9·7	9·7	*U* gauged 9·7. *c* 9·2 gauged. *g* several tenths brighter than *h*. A clear sky, but high wind from W., almost a gale.
	8 30	...	... ...	9·7 gauged	...	A gale blowing.
	9 0	70	$b+5$; $d-5$...	...	...	Unchanged. Abt. 9¾ mag. Bluish white, "looms large."
27	7 0	70	$b+5+6$; $d-6+5$	9·7 9·8 9·7 9·8	9·75	Gauged 9·7. $b=c$ 9·2 (*c* as one star) white. Not changed since last night, I think. Not sharply defined. A gale blowing. Sky clear between occasional driving clouds. *g* a tenth or two $>h$.
30	10 30	70 110	$b+4+5$; $d-7-6$	9·6 9·7 9·7 9·6	9·65	Gauged 9·7. A brilliant night. *U* not less than on the 27th?
			$b+5$; $d-6$..	9·7 9·7	9·7	Sharply defined. Slight orange tint? $b=c$ 9·2. (Jan. 28, 29 cloudy. Jan. 31, Feb. 1 cloudy. No obs.)
Feb. 2	11 50 12 5	70 110	$b+4$; $d-7$; $a+10$	9·6 9·6 9·6	9·6	$b=c$ 9·2. *U* gauged 9·6. *U* white. A heavy gale all day. Gale subsiding. *U* not so sharply defined as *b* or *c*. *b* slightly ruddy. *U* most certainly *not* so bright as *b* or *c*, tried in focus and out. So, too, in finder. *g* a tenth or two $>h$. Definition bad.
3	7 15	70 110	$c+5+6$; $d-5$	9·7 9 8 9·8	9·8	Gaugings of stars. *a* 8·6; *b* 9·2 9·3?; *c* 9·2; *d* 10·3; *e* 10·5; *U* 9·7 9·8. *U* white. I think no orange tint. *b* ruddy and slightly less than *c* (as one star).

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1883. Feb. 4	h m 8 35	70 110	$=d$; $e-2$	10·3 10·3	10·3	*d* 10·3; *e* 10·5. *U* gauged 10·3 10·4. Light a little unsteady? with 110 *white.* I think no tinge of orange in it. It is *not bluish.* Evidently fading. *b* (ruddy) $=c$?
5	7 3	70	$e+1+2$; $f-5$	10·6 10·7 10·7	10·7	10·7 gauged. $b=c$. *f* 11·2 gauged. ✱ to the south of *k* 11·0 gauged.
6	7 0	70 110	$=f$	11·2	11·2	*White.* Gaugings *U* 11·2, *f* 11·2, ✱ S. of *k* 11·0, *g* 11·8 11·9, *h* 12·3.
13	7 13	110 191	$l+3$	14·0	14·0	*l* well seen. *U* glimpsed. Star between *U* and *k* glimpsed. *g* several tenths greater than *h*. Confused vision.
16	9 50	110 235	Not seen ...	Under 13·3	<13·3	*k* seen. Moonlight and haze.
22	9 45	110	Not seen ...	Under 13·3	<13·3	*k* seen. *g* but little, if at all, brighter than *h*. Moonlight.
23	7 10	110	Seen at times	14?	14?	*l* seen well. $g=h$.
24	8 0	110	... ...	14·2 14·3?	14·25?	*l* well seen. *U* well seen at times, several tenths less than *l*. Small star between *U* and *k* also seen. Barely so bright as *U*?
Mar. 16	8 45	110	Not seen. Under 13·7	Under 13·7	<13·7	*k* and *l* well seen. Qu. *U* glimpsed? *g* a tenth or two $>h$.
23	7 58	110	Not seen ...	Under 13·3	<13·3	*k* seen. *l* glimpsed?? $g\ 2>h$. Bright moonlight.
30	8 40	110	$l+2+3$ ...	13·9 14·0	13·95	*l* well seen. Small star between *U* and *k* seen also. $g=h$?
Apr. 1	12 35	70	Not seen ...	Under 12½	<12½	*g* and *h* well seen. *k* glimpsed at times.
2	8 45	110	$l+3$? ...	14±	14±	Clearly seen, as also *l* and the star between *U* and *k*.
4	9 15	110	$l+3$? ...	14±	14±	Well seen, as also star between it and *k*. *l* well visible and a tenth or two $>U$. *g* barely so bright as *h*.
7	9 0	110	Glimpsed $l+5$?	14·2	14·2	*l* well seen. *U* glimpsed at times. *g* less than *h* by a tenth or two?
25	8 59	110	13·8; 14? Glimpsed	13·8 14	13·9	Rather hazy. *k* and *l* seen.
May 1	9 25	110	... ...	13·7 14±	13·85?	*k* and *l* seen. *U* seen at times. Flashes up at times.
4	9 50	110	... ...	13·7±	13·7±	*k* well seen. *l* glimpsed. *U* flashes out at times 13·7 13·5. Bad definition and sky not very clear.
6	9 45	70 115	Not seen ...	Under 13·3	<13·3	Certainly under 12·5. *k* well seen at times but not always. Definition very bad. High wind, N.E., and haze in sky. *c not seen double!*
7	9 45	110	Glimpsed at times	13·7 14	13·85?	*k* well seen. *l* glimpsed at times, also *U* at times. *g* not equal *h*. $=h+3$. *U* 13·7 14 mag. Certainly not so bright as *k* 13·3.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1883. May 15	h m 10 5	70 115	Not seen ...	Under $12\frac{1}{2}$	<12·5	A hazy sky with moonlight. *g* and *h* seen. *k* glimpsed?? Field flooded with light and stars seen with difficulty.
16	9 58	70 115	Not seen ...	Under $12\frac{1}{2}$	<12·5	Observation made with great difficulty. Moonlight and haze. *g* and *h* seen. *k* not seen at all.
31	10 0	70 110	Not seen ...	Under 10? Certainly under 9·5	<10? Certainly <9·5	*b* and *c* well seen. None of the *U* group seen at all. *d* perhaps glimpsed.
June 1	10 0	70 115	Not seen ...	Under $9\frac{1}{2}$	<9·5	*b* and *c* well seen. No star of group about *U* visible. *d* perhaps glimpsed. Field flooded with twilight and stars low.
Oct. 20	11 20	115	Not seen ...	Under 11·2	<11·2	Field flooded with moonlight, and 6 hrs. from meridian. *a b c* well seen, as also *d e f* and ✱ abt. = *f* south of *k*. Observation difficult and doubtful.
Nov. 7	11 50	115	= *l*	13·7	13·7	Sky a little hazy. *U* and *l* well seen at times. *g* 5 > *h*?
10	10 50	115	Not seen ...	Under 12	<12	Definition very bad and sky hazy. *g* about 11·8. *h* glimpsed. *k* and *l* not seen. *g* = *f* + 6 *h* − 5? *a*, *b*, and *c* like pellets of wool!!
16	10 20	115	Not seen ...	Under 12	<12	Doubtful observation. Moonlight and haze. *h* glimpsed. *g* 11·7.
21	10 15	115	... ...	Under 13·5	<13·5	*k* well seen. *l* glimpsed. *U* glimpsed?? *g* 11·8 ± $\frac{1}{2}$ mag. > *h*.
26	10 30	115 191	... ...	Under 13·7	<13·7	*k* well seen. *l* fairly. Qu. *U* glimpsed at times? *g* abt. 11·8.
Dec. 6	8 40	115	Not seen ...	Under 12	<12	*g* (12·0 est.) and *h* seen. *k* not seen. A gale blowing from N.E. (or almost a gale). Slight snow on ground. Cold.
21	8 35	70	Not seen ...	... ...	...	*a*, *b*, and *c* seen. No other stars. Cloudy.
1884. Jan. 12	8 15	70	Not seen ...	... ...	...	Only *a*, *b*, and *c* seen. Field flooded with light from full Moon near, and much haze in sky. The definition very bad. Haze over sky. (Ice crystals?)
24	8 10	115	= *h*... ...	13 3	13·3	Well seen. Careful comparison. *l* seen. *g* about equal *h*. Light of *U* a little unsteady? Obs. confirmed with 191.
26	9 50	70	*c* + 4; *d* − 7...	9·6 9·6	9·6	9 6 gauged. White. Largish disc? *b* ruddy. Slightly > *c*? Obs. rather uncertain. A high wind. A severe gale subsiding. (A gale last night, Friday, Jan. 25. No obs. possible.)
27	8 53	70	*a* + 11; *c* + 5	9·7 9·7	9·7	$9\frac{3}{4}$ est. Observed with difficulty. Among clouds. Qu. *e* brighter than 10 6? Decidedly so, I think, more like 10 0. N.B.—Obs. hurried and closed by clouds which came up.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884. Jan. 28	h m 8 15	70	$c+7$; $d-3$...	9·9 10·0	9·95	9·8 10·0 gauged. Obs. difficult. A cloudy sky, with clear intervals. *e* 10·4 10·5. *U* barely so bright as last night, certainly. At 8.30 sky completely clouded over.
30	9 0	70	$f+2$? ...	11·4?	11·4?	A difficult observation in a hazy sky. At times only *a*, *b*, *c* visible. At time of estimate *g* and *h* also seen. *U* not $>f$.
Feb. 2	7 20	70 115 191	$l+0+3$ ...	13·7 14·0	13·85	Clear, but definition very bad. *k* and *l* well seen. *U* at times flashes up as bright as *l*, not brighter. (Cloudy skies last night and night before. No obs. possible.) $g=h-2$, $e=d+3$ ∴ 10 6. *b* ruddy $=c$?
6	7 35	110 115	Not seen ...	Under 13?	<13	Moonlight and haze. *g* a tenth or so $>h$. *k* doubtfully glimpsed at times. *l* not seen.
25	7 45	115	Glimpsed at times?	... ...	...	*k* and *l* seen.
29	7 44	89	Glimpsed at times	14 ±	14 ±	*k* and *l* seen.
Mar. 5	8 53	115	Not seen ...	Under 13·3	$<13·3$	*k* glimpsed at times. Moonlight and haze.
Apr. 8	10 25	70	... ...	... ...	...	A very hazy sky. Only *a*, *b*, *c* seen.
16	8 45	70 115	Glimpsed? ...	14	14 ±	*k* well seen. *l* glimpsed. *U* glimpsed.
21	8 30	115 191	Seen by glimpses	14 ±	14 ±	*k* well seen at times. *l* glimpsed.
May 20	9 50 10 5	70 115	... ...	11? 11·2?	11·2??	Sky hazy. *a*, *b*, *c* well in view. *d* seen, also *e*. I believe, too, I see at times *f*, *U*, and star above (south of) *k* nearly equal to *f*. If so, *U* not >11 mag $=f$? 11·2? *U* certainly not so bright as either *d* or *e*. Obs. made with great difficulty. A heavy bank of cloud and haze along west horizon, reaching to some height. (Defin. bad. *c* not seen double.) Obsd. in consequence of letter from Mr. Baxendell dated 1884 May 19, in which he says: "*U* Geminorum. 1884 May 18, 10^{h} 30^{m} G.M.T. $c12>U$ $5>e$, but very low, and strong twilight and observation interrupted by cloud."
Oct. 18	11 45	115 191	Not seen? ...	Under 13·3	$<13·3$	*g*, *h*, and *k* seen. *g* a tenth or two greater than *h*. *l* not seen. Qu. *U* at times glimpsed? Very, very doubtful.
22	11 40	70	$c+2$; $d-9$...	9·4 9·4	9·4	$b=c-1-0$. *U* white and rather large. *b* yellowish, not ruddy.
	12 0	70	$c+2$; $d-9$; $\frac{1}{2}(a+d)$	9·4 9·4 9·45	9·4	*U* certainly not so bright as *c*. $b=c$. Various apertures, full, 4^{in}, 3^{in}, so also in finder. $g=$ or a tenth or so brighter than *h*.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884. Oct. 23	h m 11 20	70	$c+2$; $a+9$...	9·4 9·5	9·45	A brief glimpse between clouds. Much the same as last night. White. $b=c$. A rather unsatisfactory observation.
24	11 45	70	$\frac{1}{2}(a+d)$; $c+2+3$	9·45 9·4 9·5	9·45	9·5 gauged. White. $g=h-2$. $b=c$.
25	11 25	70	$a+9$; $c+3$...	9·5 9·5	9·5	Much as last night. White. Caught between clouds. *a, b, c, d*? *e*? seen. A high wind blowing.
26	11 5	70	$a+9$; $d-8$; $c+3$	9·5 9·5 9·5	9·5	White, clear sky, high wind. $b=c+1$. Orange tint. *U* rather large disc?
28	11 15	70	$c+10+11$; $d-1-0$	10·2 10·3 10·2 10·3	10·25	$c1>b$. *b* ruddy. $g=h$. $h-1$.
	11 50	70	$d-1$... ...	10·2	10·2	*d* 10·3, *e* 10·5. $U=e-3$.
31	11 45	115	$h-0-1$ ...	12·3 12·2	12·25	A hazy sky and clouds troublesome. $g=h-2-3$. (On the 29th clouds came over soon after 9 o'clock, and no obs. of *U* possible. The 30th was cloudy also.)
Nov. 7	11 10	115	Not seen ...	... ...	...	Field quite lost in haze and moonlight. Moon near. Only *a, b, c* seen.
Dec. 9	10 0	115	Not seen ...	Under 13·5	<13·5	*k* and *l* seen. $g=h-3$. (Baxendell, 1884 Dec. 20, 12^h, $U=$ about 13·7.)
1885. Jan. 6	9 10	115	$f+6$; $h-5$...	11·8 11·8	11·8	Large, bluish, hazy. A bright 12 mag. About $=g$ which $=h-5$.
	11 0	115 191	$f+7$; $h-3-4$	11·9 11·9 12·0	11·9	Slightly bluish white, ill-defined, light rather unsteady. About $=g$, which is 3 or 4 tenths $>h$. *U* gauged 11·9 12·0 *h* 12·3.
7	8 44	115 191	$h+8$; $k-2$...	13·1 13·1	13·1	Light a little unsteady. White, a little large? *Not ruddy.* *b* ruddy, $=c+1$, $g=h-1$.
	8 50	115	$=k$	13·3	13·3	Light of *U* unsteady. Now it is no brighter than *k*. (Baxendell, 1885 Jan. 7, 10^h 5^m. $U=12·9$.)
20	10 20	115	Not seen ...	Under 13·5	<13·5	*k* well seen. *l* once or twice glimpsed.
Feb. 5	8 20	115 191	Glimpsed? ...	14 14½	14·3	*l* well seen at times. *U* glimpsed and *U*'s comes?? $g=h-3-5$? $f+6+7$.
9	9 15	115	Not seen ...	Under 13·3	<13·3	*k* seen. *l* not seen. A rather hazy sky.
18	8 30	191 110	$l+3+5$ ...	14·0 14·2	14·1	*k* and *l* well seen. *U* also well seen, as though flashing up to 14 mag. at times. Comes between *U* and *k* glimpsed.
19	9 10	115	Not seen ...	Under 13·3?	<13·3?	Certainly under 12·3. $g=h$. *k* glimpsed at times. Hazy. Clouds quite obliterating the field at times.
21	...	115?	Not seen ...	Under 13·5	<13·5	*k* well seen. *l* glimpsed.
Mar. 7	7 40	191	Glimpsed ...	14¼?	14·25?	*k* and *l* well seen. *U* glimpsed, also *U*'s comes? *U* less than 14 mag.? $g=h$.
10	8 10	115	Glimpsed ...	14±	14±	*k* and *l* well seen. $g=h$.
11	9 0	115	Not certainly seen	Under 13·7	<13·7	*k* well seen. *l* glimpsed at times.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885.	h m					
Mar. 14	8 47	110	Glimpsed. $l+3$?	14	14	k and l well seen. $g=h$, not greater than h.
17	8 0	110 200	$l+3$... ...	14·0	14·0	k and l well seen. U well seen, a few tenths less than l. Small comes between U and k also pretty steadily seen.
18	8 25	110 115	... ...	Under 13·3	$<13·3$	k well seen at times. l and U glimpsed at times? Not a clear sky. $g=h$.
19	8 40	115	Not seen ...	Under 12·3	$<12·3$	g and h seen, $g=h$, an unsatisfactory observation. A very hazy sky.
	10 25	115	Under 13·3 ...	Under 13·3	$<13·3$	k pretty well seen. Qu. l and U glimpsed? $g=h$.
20	8 20	110 115	... ...	Under 13·5	$<13·5$	k well seen. l glimpsed at times. U glimpsed once or twice. A high wind and not very clear sky.
23	10 10	115 200	Not seen ...	Under 13·3	$<13·3$	Certainly under 12·5. g and h well seen. k glimpsed. A hazy sky and moon rather near, about 1st quarter. $g=h-1-2$.
27	8 15	110 115	Not seen ...	Under 12·3	$<12·3$	g and h seen. k glimpsed? Moonlight and a very hazy sky. $g=h-1$? A high wind from N.W.
28	9 50	115 110	Not seen ...	...	$<12·3$?	Certainly under 11·3, not so bright as either f or star S. of k, and probably not so bright as 12·3. g and h seen at times only. Moonlight and hazy sky, and vision execrable.
30	8 35	110 115 200	Not seen ...	Under 13	<13	g and h well seen. k pretty well seen at times. Moonlight and hazy sky. A bad night for faint stars.
31	9 50	115	Not seen ...	Under 12·3	$<12·3$	g and h seen. A very dull, hazy sky. Moon rising.
Apr. 1	8 30	115 200	Seen at times	14·5	14·5	A clear sky. k and l well seen. U and U's comes seen at times. U seems to flash up some tenths at intervals. g 2 or 3 tenths $>h$.
3	7 55	115 200	Well seen. $=l$	13·7	13·7	Clear sky. N.E. wind, high. U well seen. Light a little unsteady? $g=h$.
	10 15	115	$l-4=k$ ...	13·3 13·3	13·3	Brightening up.
	12 15	115 191	... ...	...	...	U and k doubtfully glimpsed? U *not* $>k$. Hazy, Moon rising. 5^h from meridian.
4	9 0	70	$c+8$; $d-3$ ...	10·0 10·0	10·0	White. Large ill-defined disc, hazy appearance.
	11 0	70	$c+7$; $d-4$ ...	9·9 9·9	9·9	c 9·2, b 9·3, U 9·9 (all) gauged $g=h$. U white. Not sharp.
5	8 0	70 38	$c+2+3$; $d-8-9$	9·4 9·5 9·5 9·4	9·45	9·4 gauged.
	8 15	70	$c+2$; $d-9$...	9·4	9·4	Light of U decidedly unsteady. $3\frac{1}{2}$ aperture.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885. Apr. 5	h m ...	...	$\frac{1}{2}(a+d)$	9·45	9·45	*U* white, fairly sharp but light unsteady.
	8 30	...	... ...	9·4 9·5	9·45	$g=h$. *k* and *l* seen.
6	8 10	70 110	$a+9$; $c+3$; $d-8$	9·5 9·5 9·5	9·5	White, slightly ill-defined? Light certainly unsteady. Gauged 9·5, *b* gauged 9·3, *c* 9·2. At times *U* looks more like 9·8 or 10.
	9 50	...	... ...	...	9·55	9·5 9·6 gauged.
9	8 15	70	$c+1$	9·3	9·3	Quite as bright as, and I think certainly brighter than, on the 5th. *b* ruddy, nearly $=c$. *U* in finder and in telescope nearly as bright as *c*. Obs. in clear intervals between clouds. The nights of the 7th and 8th were hopelessly cloudy. Certainly not less bright than on the 5th.
	8 30	70 115	$a+6+7$; $c+0+1$; $d-10-11$	9·2 9·3 9·2 9·3 9·2 9·3	9·25	White or bluish white, *sharply defined.* Both in telescope and in finder equal or nearly so to *c* (as one star). *b* ruddy $=c+1$. $U=$ or slightly $>b$. Clearer now, and obs. more satisfactory. $g=h$. *U* with 115 well defined and sharp. *Not hazy.*
11	10 0	70	$c+2$; $b+1$; $d+8$	9·4 9·4 9·4	9·4	White, observed in clear intervals between clouds. *b* orange ruddy $=c+1$. In finder *U* well seen and estimated much as in large telescope.
	10 12	70	$b+2$: $c+3$; $a+9$; $d-8$	9·5 9·5 9·5 9·5	9·5	Clouds troublesome.
12	8 30	70	$a+11$; $b+4$; $c+5$; $d-6$	9·7 9·7 9·7 9·7	9·7	9·7 gauged. On the wane apparently. With 115 pretty sharply defined. White. $g=h$.
13	8 15	38	$d+0+1$ $\frac{1}{2}(b+f)$ but nearer *f*	10·3 10·4 10·3	10·35	Between clouds.
	8 30	38	$e-2$; $d+1+2$; $b+11$; $f-8$	10·4 10·4 10·5 10·4 10·4	10·4	In clear sky. *b* ruddy $9·3=c+1$. At 8 40 clouded over thickly.
14	9 50 10 40	...	... ...	...	...	Watched in vain for $\frac{3}{4}$ of an hour for chance of obs. of *U*. *b* and *c* glimpsed once or twice.
16	11 25	115	$h+5+6$; $k-4-5$	12·8 12·9 12·8 12·9	12·85	Looms large? Obs. difficult. Stars rather low and sky not clear.
	11 35	...	$h+5$; $k-5$ ...	12·8 12·8	12·8	*U* large and pretty constantly seen. *k* seen well by glimpses. *U certainly not less* than 13·0. $g=h$.
	11 40	115	$h+5$; $k-5$...	12·8 12·8	12·8	A fair obs. under difficult circumstances. *U* not rated too high, pretty certainly. *U* certainly not so bright as either *g* or *h*.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885. Apr. 17	h m 8 30	115 200	$k-1$; $l-5$; $h+9$	13·2 13·2 13·2	13·2	Clear sky, stars well seen, but definition not very good. *U* large and ill defined. $g=h+1$.
	9 10	115	$k-1-2$; $h+8+9$	13·1 13·2 13·1 13·2	13·15	
	9 50	115 191	$k-2$; $l-6$; $h+8$	13·1 13·1 13·1	13·1	Well seen and certainly $>k$. Rather large? White.
18	8 30	115 200 110	$k+4$; $=l$ ...	13·7 13·7	13·7	
	9 5	191	... ...	13·6 13·7 13·6 13·7	13·65	*U* and *l*, when both seen well, very nearly equal, if not quite so.
19	8 40	110 115 195	$l+3$? ...	14	14	Sky rather hazy and Moon not far off. *k* well seen. *l* and *U* well seen at times, when so *l* certainly the brighter. $g=h+2$.
20	8 30	110 195	Not seen ...	Under 13·7 ?	$<13·7$	*k* well seen. *l* glimpsed? Moon near and field flooded with light.
21	8 30	110	Not seen ...	... ...	...	*k* not seen. *g* and *h* seen. *g* 2 tenths less than *h*. Moon bright and near.
Oct. 27	10 20	70	Not seen ...	Under 9·3	$<9·3$	*a*, *b*, *c* well seen. *d* not seen. 7^h from meridian, and Moon rather near.
Nov. 7	10 30	115	Not seen ...	Under 13·3	$<13·3$	*k* well seen. *l* not seen. Stars low.
17	10 0	115	Not seen ...	Under 12½	$<12·5$	*g* and *h* seen. Moonlight. Poor definition.
Dec. 1	10 40	191	Not seen ...	Under 13·3	$<13·3$	*k* seen. *l* not seen.
10	10 0	70 115	$c+10$; $d-1-2$; $f-10$	10·2 10·2 10·1 10·2	10·2	White. Large disc? *e* about same mag.? Sky not quite clear, and observation a little difficult.
15	8 50	191	Glimpsed? ...	13·7?	13·7?	*k* well seen. *U* and *l* glimpsed.
	10 25	110 115 191	... ...	...	13·7?	*l* and *U*? glimpsed at times. *U* not $>13·7$. *k* well seen. Moonlight and sky rather hazy.
1886. Mar. 11	7 45	70 115 191	$c+4$; $d-7$...	9·6 9·6	9·6	9·6 gauged. *c* 9·2, *d* 10·3. *b* ruddy $=c$? *U* white and fairly sharply defined (115 191). Clear, and East wind. $g=h-2$. *b not* $>c$.
13	9 5	70	$c+9$; $d-2$; $f-11$	10·1 10·1 10·1	10·1	Obs. difficult owing to haze and moonlight. *U* white. Fairly defined. Nearer in mag. to *c* than *f*.
14	8 30	70 115	$c+13$; $d+2$; $f-7$; $e-1$	10·5 10·5 10·5 10·5	10·5	White. Fairly defined. *b* very decidedly ruddy and perhaps slightly brighter than *c*. *U* not *below* 10·5. Moon rather near and cloud and haze. At 8 40 clouds drove over the sky from the N.E.
15	10 40	115 191	$f-2$; $e+4$; $d+7$	11·0 11·0 11·0	11·0	Moon near, and hazy. Obs. very difficult. *g* and *h* seen at times. *h* rather brighter than *g*? *U* about 11 mag. Obs. a little doubtful.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1886. Mar. 16	h m 8 10	70 115	Not seen ...	... ...	...	Moon bright and sky so hazy that only *a*, *b*, *c* seen. *b* slightly brighter than *c*.
Nov. 2	10 40	115	I think *not* seen	Under 14	< 14	*k* well seen. *l* glimpsed.
16	10 10	115	Not seen ...	Under $12\frac{1}{2}$	< $12\frac{1}{2}$	*g* and *h* seen. Obs. difficult. Moon bright and near, and stars 6ʰ from meridian.
17	10 20	110 115 191	Under 13·3 ...	Under 13·3	< 13·3	Not seen certainly, nor *l* certainly, but qu. both glimpsed at times??? very doubtful. Field lighted up by rising Moon, and 6ʰ from meridian. *g* a tenth or two greater than *h*.
29	9 0	70	$b+1+2$; $d-8-9$	9·4 9·5 9·4 9·5	9·45	White. Not quite sharply defined. $g=f+3$; $h-8$. *g* unusually bright (11·5). $b=c+1$.
	10 5	70	$b+2$; $d-8$...	9·5 9·5	9·5	White.
30	9 45	70 115	$b+2$; $d-8$...	9·5 9·5	9·5	White. Not quite sharp. $g=f+4$. $h-7$.
Dec. 1	8 55	70	$b+1$ ...	9·4	9·4	White. *b* orange ruddy. *U* not quite so sharply defined as *b* or *c*. $g=f+6$. $h-5$.
2	8 50	70 115	$b+2$; $d-8$...	9·5 9·5	9·5	Rather hazy. *U* white. $g=f+5$ $h-6$.
3	8 45	70	... ...	... ...	...	A very hazy sky. No star of group visible.
	8 55	70	$b+2+3$; $d-8-7$	9·5 9·6 9·5 9·6	9·55	Sky clearer, but very hazy still. *U* white. Obs. rather doubtful. *U* rather fainter than last night?
4	8 55	70 115	$b+3$; $d-7$...	9·6 9·6	9·6	White. $g=f+5$; $h-6$. Rather hazy and moonlight.
	9 46	70	$b+4$; $d-6$...	9·7 9·7	9·7	*b* ruddy $=c+1$. *U* white. Rather more satisfactory obs. than that at 8.55. *U* on the wane?
7	12 30	70 115 191	$d+8$; $e+5$; $f-1$	11·1 11·1 11·1	11·1	White. Rather large? $g=h-5$; $f+6$. Obsd. in a clear interval between clouds. Satisfactory to the senses.
8	9 45	115	$f+5$; $h-6$; $=g$	11·7 11·7 11·7	11·7	$g=f+5$. A gale blowing. Moon bright. Stars not well defined. *k* visible. Obs. difficult and a little uncertain. Haze over sky.
	9 55	110	$f+5$; $h-6$; $g-0-1$	11·7 11·7	11·7	$g=f+5+6$.
15	9 10	191	Glimpsed? Under 13·5	...	< 13·5	*k* well seen. *l* glimpsed. Qu. *U* also glimpsed? $g=h-4$. Moon rising. Sky not clear.
16	8 50	115 110 191	Not seen *certainly*	Under 13·7?	< 13·7?	*k* well seen. *l* seen at times. $g=h-3-2$.
	10 10	191 115	... ...	14 ±	14 ±	Seen at times, as also once or twice comes. 14 mag. ±? *k* well seen. *l* seen.
1887. Feb. 1	8 30	115	Not seen ...	Under 13·5	< 13·5	*k* well seen. *l* glimpsed at times. $g=h-5$? Rather hazy and Moon 1st quarter.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887. Feb. 8	h m 8 45	191	Not seen ...	Under 13·3	<13·3	k seen. l not seen. $g=h-3$.
12	10 5	110 115 191	Glimpsed? ...	14·5 ± ?	14·5 ± ?	k and l seen. U glimpsed at times.
14	8 55	115 110	$l+3$... ...	14·0	14·0	k well seen, so too l, and U clearly seen at times, abt. 14 mag. $g=h-3$.
15	8 15	191	$l+2+3$ ...	13·9 14·0	13·95	l well seen. U also well seen at times, 2 or 3 tenths less than l, and U's comes (still fainter) glimpsed at times. $g=h-2$.
16	8 45	115 110	$=l$	13·7	13·7	Light of U rather unsteady. At times fully equal l, at times a tenth or so less seemingly. $g=h-0-1$?
	10 25	115	$l+2+3$ ...	13·9 14·0	13·95	Barely flashing up to l in brightness as at 8·45. U's comes also seen at times.
17	8 10	115 110 191	... ...	14 14+	14 ±	Light a little unsteady, at times brightening up to about 14. Two or three tenths less than l which is well seen. U's comes between U and k (m say) seen at times. Rather fainter than U.
21	8 10	70	Not seen ...	Under 12·3	<12·3	f, h, g seen. A hazy sky and obs. very difficult and unsatisfactory.
	9 0	115	$l+0+3$ ...	13·7 14·0	13·85 ±	Fairly clear. l and U glimpsed at times. ∴ U *certainly less* than k, which was well seen.
	9 55	115 191	$l+0+3$ ...	13·7 14	...	Fairly clear sky. $g=h+1$?
25	7 50	70	$=d$; $e-3$ ...	10·3 10·3	10·3	White. Light dull? $g=h+3$ U gauged 10·3.
	11 0	70	$d+2$; $e-1$...	10·5 10·5	10·5	Barely so bright as it was?? White. Light a little unsteady?
26	7 15	70	$e+3$; $f-3$...	10·9 10·9	10·9	Gaugings e 10·6, f 11·2, U 10·9. White. Dull. Light a little unsteady?
	9 50	70 115	$d+6$; $e+3$; $f-3$	10·9 10·9 10·9	10·9	White, not sharp.
27	8 50	70 115 110	$f+4$; $h-7$...	11·6 11·6	11·6	Abt. 11·5 gauged. White. Light unsteady. Not easy precisely to satisfy oneself as to estimates of magnitude. Definition bad.
28	7 10	70 115	$h+5$; $k-5$...	12·8 12·8	12·8	U white. $g=h+2$. U gauged 12·7 12·8.
Mar. 1	7 50	115	$k+2$; $l-2$...	13·5 13·5	13·5	Well seen, though sky a little hazy and Moon rather bright. $g=h+2+3$?
2	8 50	115 110 191	14 est. ...	14	14	k well seen. l seen well at times. U glimpsed at times. Hardly equals l when seen. Sky rather hazy, and moonlight. Obs. difficult. $g=h+2$?
12	3 0	110	... ...	14·5 ±	14·5 ±	k and l well seen. U and comes glimpsed at times. $g=h$.
Apr. 8	8 40	191	Not seen ...	Under 13·7	<13·7	l glimpsed. $g=h$?
16	8 50	191	... ...	14·5?	14·5?	U and U's comes glimpsed? 14·5? $g=h+2+3$. Decidedly less than h.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887. May 10	h m 10 10	115	Not seen ...	Under 13·3?	<13·3?	k seen at times. l *not* seen. $g=h$? Stars $5\frac{1}{2}^h$ past meridian and sky rather hazy.
20	10 0	115 191	Not seen ...	Under 13·3	<13·3	k seen at times well. Obs. difficult. Sky not clear.
Oct. 11	12 30	115 191	Not seen ...	Under 13·3?	<13·3?	g and h well seen. ($g=h$.) k glimpsed at times. U not seen.
Nov. 15	10 25	115	$=l$? $k+4$?	13·7?	13·7?	l and U seen at times. k well seen. $g=h-5$?
30	10 0	115	Not seen ...	Under 12·5	<12·5	g and h seen. Obs. difficult. Field flooded with light. Moon and haze. g a little brighter than h. g and h seen with some little difficulty at times.
Dec. 5	9 40	115	Not seen ...	Under 12·3	<12·3	g and h well seen. $g=h-2-3$. k glimpsed? Hazy, and Moon rising.
15	8 50	191	Not seen ...	Under 13·5	<13·5	k seen well. l not seen, or glimpsed? g 2 or 3 > h.
1888. Jan. 9	9 0	115	$=g$; $h-3$; $f+8$	12·0 12·0 12·0	12·0	$g=h-3$ (∴12·0). k seen. Definition poor. Rather hazy.
	12 0	115	$g-1$; $f+7$...	11·9 11·9	11·9	Gauged 11·9, g 12·0, $g=h-3$, k and l seen. U unchanged? or slightly brighter?? Light of U unsteady. Disc hazy?
10	8 50	70 115 191 110	$h+6$; $k-4$..	12·9 12·9	12·9	Light of star very unsteady.
18	8 15	115 191	Glimpsed at times; $l+3$	14·0	14·0	l well seen at times. $g=h-3$.
Mar. 1	8 5	191	Glimpsed ...	14·5?	14·5?	l well seen. $g=h-3$.
5	7 50	115 191	Glimpsed; about $14\frac{1}{2}$	14·5	14·5	l well seen. $g=h-5$.
21	7 30	115	Not seen ...	Under 13·3	<13·3	k glimpsed. $g=h-5$. Moon, 1st quarter, near.
Apr. 11	11 25	115	Glimpsed ...	14 14·5	14·25	k and l seen. U less than l decidedly. $g=h$?? Clear, but high wind.
14	9 0	115	$l+5+7$ ...	14·2 14·4	14·3	Glimpsed. k and l well seen. $g=h$. Wednesday afternoon, April 18, received telegram from M. J. Baxendell, Birkdale Obsy., as follows: "Variable *Gemini* last night 9·3 mag. Baxendell, Birkdale."
20	11 55	70	$c+3$?? ...	9·5??	9·5??	a, b, c seen. $c=b-1$? U seen once or twice. A very doubtful obs. In small gaps between clouds. I am pretty sure I saw U.
21	8 20	70	$d+2$; $e-1$...	10·5 10·5	10·5	Among clouds. Obs. difficult. $c1>b$. b ruddy. Obs. in a clear interval between clouds. f visible, also star of about same mag S. of k. Obs. rather hurried. Clouds came over.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1888. Apr. 26	h m 9 45	115	Under 13·3 ...	Under 13·3	<13·3	*k* well seen. *l* not seen. Qu. *U* glimpsed once or twice? 13·5? *g*=*h*. Moonlight and sky not clear. *b* ruddy=*c*? *c*−1?
30	9 40	70 115	Not seen ...	Under 13·7	<13·7	*k* and *l* visible. *g*=*h*? *b* ruddy=*c*−1.
Oct. 5	12 15	115	... ...	...	...	Not seen? or glimpsed once or twice?? *k* well seen, *l* occasionally. *U* certainly under 13·3. Almost certainly *not* so bright as 13·7. Qu. *U* 14±? Low, and rather hazy sky. *g* 1 or 2>*h*.
11	12 45	70	Not seen ...	Under 10	<10·0	*a*, *b*, *c*, *d*, *e* seen. *Very hazy.* *d*, *e* only at times. Qu. once or twice *f* and star about equal to *f* near *k*? Very hazy, with light filmy clouds. Observation very difficult and uncertain. *b* slightly greater than *c*??
13	12 0	70 110 115 191	Not seen ...	Under 12·5	<12·5	*g* and *h* well seen. *g*=*h*. *k* glimpsed once or twice. *b*=*c*−1. Ruddy. Hazy.
15	12 30	70 110 115	Not seen ...	Under 12·3	<12·3?	Certainly under 11·2. *f* well in view. *g* and *h* at times well seen. *g*=*h*. *k* not seen at all. A hazy sky glared over by moonlight. Obs. very difficult and uncertain.
19	12 45	110 115	Not seen ...	Under 12·3	<12·3	*g* and *h* well seen. (*g*=*h*.) *k not* seen. *b*=*c*−1.
22	12 15	115	Not seen ...	Under 12·3	<12·3	*g* and *h* seen. *g*1>*h*? *k* not seen. Moon bright, and light clouds and haze troublesome. Observation difficult.
23	11 35	115	Not seen ...	Under 11·2	<11·2	Certainly under 11·2. Qu. almost certainly under 12·3? *g* and *h* glimpsed at times. Hazy sky, and Moon bright and rather near.
27	11 30	115	Not seen ...	Under 12·5	<12 5	*g* and *h* well seen at times. Light clouds, and Moon rising. *g*=or barely=*h*. *k not* seen.
30	11 30	70 115	*d*+4; *e*+1; *f*−5	10·7 10·7 10·7	10·7	Slightly ruddy?? Light unsteady? *g*=*h*. *k* seen. *U* rather large disc?
	12 15	70	*d*+4; *e*+1; *f*−5	10·7 10·7 10·7	10·7	(N.B.—Sky rather hazy and obs. not easy.) [Note added Oct. 31.]
Nov. 6	11 10	115 110 191	*k*+1; *l*−3...	13·4 13·4	13·4	*b* ruddy. 1>*c*. *l* glimpsed at times. Clear at times, but bad definition. Cold strong wind from E. *g*=*h*. Light of *U* unsteady. At times almost equal *k*. (First chance of observing *U* since 30th ult. Clouds came up on 3rd and 5th before obs. of *U* were possible.)
Dec. 7	10 20	115	Not seen ...	Under 13·3	<13·3	*k* seen. *l* not seen. Hazy.
12	8 45	115	Not seen ...	Under 13·3?	<13·3?	*g*=*h*. *k* seen at times. *l* not seen.
26	9 58	115	Not seen ...	Under 13·3	<13·3	*k* seen. *l* not seen. *g*=*h*−1.
1889. Jan. 1	9 45	115	Seen at times	14 $14\frac{1}{2}$?	14 $14\frac{1}{2}$?	*k* and *l* seen. *U*'s comes seen at times. *g* 2 or 3 tenths>*h*.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889. Jan. 20	h m 7 40	115 191	$=l$; $k+4$ ...	13·7 13·7	13·7	$g=h-3-4$. b ruddy $=c-1$ (c as one star). U perhaps at times a tenth or so brighter than l.
21	9 45	70 115	$d+3+4$; $c+0+1$; $f-6-5$	10·6 10·7 10·6 10·7 10·6 10·7	10·65	Large. White. At times barely equals e. Bad definition and clouds troublesome. $g=h-3$. Heavy clouds came over at 9^h 55^m.
22	9 40	70 115	$c+3$; $d-8$...	9·5 9·5	9·5	9·4 9·5 gauged. c gauged 9·2 (as one star). b ruddy 9·1 9·2. U white and pretty sharply defined. $g=h-4-5$. *U certainly decidedly less* than either b or c.
23	11 45	70	$c+2$... ...	9·4	9·4	About as bright as, or slightly brighter than, last night. A very hazy sky. Only e and f seen. U white and fairly sharp. Obs. difficult and unsatisfactory. b ruddy. Slightly brighter than c? At 11^h 55^m g seen but not h.
26	10 30	70	$c+3$... ...	9·5	9·5	Unchanged apparently. White. Hazy and cloudy sky. Only a, b, c, d seen.
27	7 30	70	$c+5+6$; $d-6-5$	9·7 9·8 9·7 9·8	9·75	Gauged 9·7 9·8. Evidently on the decline. White and pretty sharply defined. $g=h-4$. b ruddy $=c-1$.
29	7 30	70	$c+4+5$ ...	9·6 9·7	9·65	Gauged 9·6 9·7. c gauged 9·2. b ruddy $=c-1-2$. With 115 U white and fairly sharply defined. Qu. f a tenth or two less than 11·2 mag.? $g=h-4-5$. Sky not quite clear.
30	11 5	70	$c+5$; $d-6$...	9·7 9·7	9·7	Gauged 9·7. Not much changed? f about 11·2. $g=h-3$. Sky not clear.
Feb. 2	7 15	70 115	$c+5$; $f-1$...	11·1 11·1	11·1	
4	7 50	191	$=k$; $l-4$ ...	13·3 13·3	13·3	Fairly defined. A little hazy? Not quite so sharp as k? Small star between U and k seen at times. $g=h-3$. *U's* comes nearly in mid-distance between U and k, rather nearer to U? f gauged 11·2. Star above k (*i.e.*, S. of k) 11·1.
7	7 30	191	$k+3$; $l-1$...	13·6 13·6	13·6	In clear space between clouds. Light of U unsteady? At times $k+2$, $l-2$? Sky very clear in intervals between clouds.
	8 0	191	$=l$	13·7	13·7	In clear space after clouds. Small star between U and k glimpsed once or twice. $g=h-1$.
	8 10	110	$=l$	13·7	13·7	Light of U to-night seems unsteady. At times a tenth or two less than l.
21	8 0	115	Seen well at times about ½ mag. less than l?	14·2 ±	14·2 ±	l well seen. *U's* comes glimpsed? $g=h$.
Mar. 1	7 30	115 191	U and comes glimpsed	14·5?	14·5 ±	l well seen. $g=h-1$. Clouds came over, no further observation possible.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889. Mar. 6	h m 8 25	115	Glimpsed at times	14?	14 ±	*l* well seen at times. *U's* comes *not* seen. $g=h-1$.
Apr. 11	8 30	115 191	Not seen ...	Under 13·3	< 13·3	*k* seen. $g=h$. *l not* seen. Light sky, moon bright and rather near.
15	8 25	115 191	Not seen ...	Under 13	< 13	Moonlight and haze. *k* seen at times. *l not* seen. $g=h$, observation difficult.
22	8 40	115 191	Under 13·7 ...	Under 13·7	< 13·7	*k* well seen, *l* seen well at times. *U* glimpsed once or twice? $g=h$.
Oct. 31	11 0	115	Not seen ...	Under 13 or 13·3	< 13 or 13·3	*k* glimpsed. $g=h$.
Nov. 2	10 50	115	Not seen ...	Under 12·3	< 12·3	*g* and *h* seen. Hazy, and stars low. Moonlight.
12	10 20	70 115	Not seen ...	Under 9·5	< 9·5	Only *a*, *b*, *c* seen. Moon near.
25	10 20	115	Not seen ...	Under 13·3	< 13·3	*k* well seen. *l* not seen. $g=h$.
30	10 5	115	Not seen ...	Under 12·5	< 12·5	*g* and *h* seen. *k* not seen. Hazy sky. $g=h+2$.
Dec. 4	9 48	115	Not seen ...	Under 12·3	< 12·3	Between clouds. Moonlight. $g=h+2$. Only *g* and *h* seen. *k not* seen.
11	9 40	70 115	Not seen ...	...	...	Very hazy sky, and Moon near. Only *a*, *b*, *c* visible. None of the stars of the *U* group to be seen.
24	8 45	115	Glimpsed ...	14 14+?	14+ ?	*l* pretty well seen. $g=h$.
1890. Jan. 4	9 0	115	Not seen ...	Under 12·3	< 12·3	$g=h-2$. *k* not seen. Bright moonlight and hazy sky.
Mar. 12	8 30	115 191	$l+2$	13·9	13·9	About 14 mag. Well seen. Comes also glimpsed. $g=h-3$.
15	7 35	115 191	$l+4$	14·1	14·1	Small star between *U* and *k* glimpsed 14·5. $g=h-3$.
21	8 0	115	... ...	...	...	*k* and *l* seen. *U* glimpsed? If not so bright as *k*, about = *l*? A very doubtful observation abruptly closed by clouds.
31	8 15	115 191	Not seen ...	Under 13·3	< 13·3	*k* seen. $g=h-2$. Field flooded with moonlight from hazy sky.
Apr. 1	8 15	115 191	... ...	Under 13·3	< 13·3	A hazy sky illumined by Moon. *k* pretty well seen. *U* and *l* once or twice suspiciously glimpsed. $g=h-3-4$.
2	8 0	191	Not seen ...	Under 13·3	< 13·3	Hazy sky. Moonlight. N.E. wind. Bad definition. *k* seen. *l* not seen. $g=h-3-4$.
4	8 10	191	Not seen ...	Under 13·3	< 13·3	*k* seen. *l* glimpsed at intervals. Very bad definition. Hazy sky and bright moonlight. $g=h-2$.
22	8 40	115	$l+3$	14·0	14·0	*l* well seen. $g=h$. *U* well seen at times.
29	8 40	115	Not seen ...	Under 12·3	< 12·3	*g* and *h* seen. $g=k-2$? Hazy and moonlight.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1890.	h m					
May 3	9 0	115 191	Not seen ...	Under 13	<13	*k* glimpsed at times. $g=h-2$. Hazy sky and bright moonlight.
5	9 45	110 115 191	Not seen ...	Under 13	<13	*k* pretty well seen at times.
13	9 50	115	Not seen ...	Under 13·3	<13·3	*k* seen. $g=h$. Stars rather low.
Nov. 1	11 23	115 110	Not seen ...	Under 12·3	<12·3	*g* and *h* (equal) seen. *k* not seen. Hazy sky and Moon near.
11	11 25	115 191	$=l$	13·7	13·7	Looms large? $g=h-2$.
24	11 45	115 110	Not seen ...	Under 13	<13	*k* seen at times. $g=h$. Very bad definition. Moonlight and hazy sky. *l* not seen. Ice haze.
Dec. 1	9 4	115	Not seen ...	Under 12	<12	Low and difficult to observe, only *g* and *h* of the small stars seen.
9	8 52	115	Not seen ...	Under 13	<13	*k* seen. $g=h$.
	10 5	115 191	Glimpsed ...	14 14·5	14 14·5	*k* well seen. *l* well at times.
10	8 57	115	Not seen ...	Under 13 5	<13·5	*k* well seen. *l* at times.
	9 55	115	Glimpsed? ...	14±	14±	*k* well seen. *l* well at times.
12	10 20	115 191	$=l$	13·7	13 7	Flashing between 14 and 13·7. When both stars well seen about equal to *l*. $g=h$ or barely so bright.
13	10 15	115	Glimpsed ...	14 14·5	14 14·5	Not so bright as 13·7. *k* and *l* seen. $g=h$. (Ink freezing in inkstand and pen!)
22	9 55	115 191 110	Not seen ...	Under 13·3	<13·3	*k* seen. *l* not seen. Bright moonlight and haze in sky. Field flooded with light. $g=h$.
1891.						
Jan. 1	9 0	191	... ...	14·5	14·5	*k* and *l* well seen. *U* and comes glimpsed 14·5±. $g=h-2-3$.
16	8 40	70	$c+3$; $d-8$...	9·5 9·5	9·5	White. Pretty sharply defined? Hazy sky, poor definition. $c=9-2$. *b* ruddy 9·0 9·1. Observed in consequence of telegram from Mr. Baxendell, received at 1^h 30^m Jan. 15. "*Last evening U Gem.* 9½ *mag. White.*" No obs. possible here on 15th, a fall of snow.
17	8 35	70	$c+7$; $d-4$...	9·9 9·9	9·9	White. $g=h-3$. *U* decidedly fainter than last night. Clear and cold, snow on ground. Ink frozen in observatory.
21	8 25	115 191	$f+9$; $h-2$; $=g$	12·1 12·1 12·1	12·1	$g=h-2$. Light of *U* rather unsteady. Hazy sky. Moon bright and near. Observation difficult. *k* seen rather feebly. Results a little doubtful. At times *U* looks hardly brighter than *h*.
Feb. 1	9 53	115 191	$l+3+5$ ...	14·0 14·2	14 1	*k* well seen. *l* well seen at times. Haze in sky giving very variable states of definition. $g=h-2$?
10	8 45	191	Glimpsed ...	14·0	14·0	*l* well seen. $g=h-1$.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1891. Feb. 26	h m 8 45	115 191	Well seen at times; $l+5$	14·2	14·2	l well seen. U well seen at times. Small star between U and k glimpsed at times. $g=h-4$. $f+7$. ∴ 11·9
Mar. 26	8 25	115 191	Not brighter than 13·7	...	< 13·7	l well seen. U glimpsed at times. $g=h-1-2$.
Apr. 1	10 5	70 115	Not seen ...	Under 12	< 12	g and h seen at times. Hazy sky. $g=h+1+2$? Observation very doubtful indeed.
6	8 35	70 115	Not seen ...	Under 13	< 13	k seen at times. Hazy sky. $g=h$.
	10 0	115 191	$l+3$	14·0	14·0	Sky clear and stars well seen. $g=h+2$. U well seen. Small star between U and k also glimpsed.
23	8 40	115	Under 13 ...	Under 13	< 13	Not seen. Under 13. k seen at times. Wretched vision!!
26	10 0	115	$l+3$? ...	14·0	14·0	k well seen, as also l well seen at times. So too U at times. $g=h$. Bad definition but fairly clear.
May 7	9 45	115	Not seen ...	Under 12·3	< 12·3	Very hazy sky. k not seen, or once or twice suspected? $g=h-2$.
11	9 40	115	Not seen ...	Under 13	< 13	k well seen at times. Hazy sky. Bad definition. $g=h-0-1$. Observation difficult. Crescent Moon rather near.
16	9 44	70	$c+3$ ...	9·5	9·5	a, b, c, and U the only members of the group visible. A very hazy sky. White skimming clouds about. A shower of snow this afternoon. U white. b ruddy. $=c+1$? Not even d visible! Moon 1st qr. about $2\frac{1}{2}$ hours away. Obsd. in consequence of a telegram from Mr. Baxendell, received about 4 P.M. on May 15: "U Geminorum about tenth magnitude yesterday evening."
Oct. 28	10 35	70 115	Not seen ...	Under 13	< 13	g and h well seen. $g=h$. k glimpsed at times.
Nov. 7	10 10	115	$=k$? ...	13·3?	13·3?	$g=h-3$.
	11 15	115	$k+1$... ...	13·4	13·4	$g=h-3$. $5\frac{1}{2}^h$ from meridian, fair seeing. l glimpseable.
9	11 15	115 191	... ...	13·6 13·7	13·65	Light unsteady, about equal to, rather brighter at times than, l. $g=h-2-3$. U decidedly fainter than on the 7th. Cloudy last night, Nov. 8.
11	11 12	115	Not seen ...	Under 13	< 13	$g=h-4$. k once or twice glimpsed. U glimpsed once or twice?? Obs. difficult. Moon-lit sky. l not seen. A very heavy gale last night and this morning from S.W., subsiding in afternoon.
1892. Jan. 4	8 43	115	Not seen ...	Under 13·3	< 13·3	k well seen. l not seen. $g=h-0-1$. Poor seeing.

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1892. Jan. 15	h m 7 55	70 115	Not seen ...	Under 9·3	<9·3	Only *a, b, c* seen. Cloud skim over sky and Moon rising. Field flooded with light.
20	8 40	70	Not seen ...	Under 9·3	<9·3	I only see *a, b, c*. Very hazy sky. *b, c* rather faint. No signs of *U* or *d*. Observation very difficult.
24	7 50	70 115	$c+3+2$; $b+2+1$; $d-8-9$	9·5 9·4 9·5 9·4 9·5 9·4	9·45	Gauged 9·4 9·5. *b* ruddy, $=c$ (as one star) + 1. U white, pretty sharply defined. *Not hazy.* $g=h-5$.
	8 55	70	$c+2$; $b+1$ ...	9·4 9·4	9·4	9·4 gauged. With 115 white and sharply defined. Clear sky. *k* and *l* seen. *b* very ruddy.
25	8 30	70 115	$c+3$; $b+2$ ...	9·5 9·5	9·5	White, sharp disc. 9·5 gauged. Not quite so clear a sky as last night. *U* about the same as last night? Light of *U* steady.
27	10 25	70 115 191	$b+3$; $d-7$ ...	9·6 9·6	9·6	White. Pretty sharply defined disc. Gauged 9·5 9·6 (9·7 as a gauging intolerable. *U* decidedly brighter than 9·7). Light a little unsteady. No haziness. *k* and *l* seen, and small star between *U* and *k* (not quite in mid-distance, rather nearer *U*) glimpsed. A high S.W. wind. Clear sky after a dull day with rain. $g=h-4$. *U* certainly rather less than it was, I think.
Feb. 1	8 3	70 115	$d+6+5$; $f-3-4$; $e+4+3$	10·9 10·8 10·9 10·8 11·0 10·9	10·9	$g=f+4$. Star above *k* 11·0. *U* white, fairly sharp. Light a little unsteady? *U* just visible in finder (2 in.) at times. 10·7 10·8 gauged. *U* may perhaps be taken to be about 10·8 mag.
2	7 28 50	70 191	$=f$; $f-1$? ...	11·2 11·1?	11·15	White, fairly defined, perhaps a little indistinct. Light a little unsteady? At times perhaps slightly brighter than *f*. Gaugings: *U* 11·2 11·1, *f* 11·2, star above (*i.e.* s.f.) *k*, 11·0, *g* 11·5, *h* 12·3, *e* 10·5 10·6. $g=f+3+4$; $h-7$. ∴ 11·5 11·6 11·6. Sky brilliant but definition rather poor. *l* well seen, and small star between *U* and *k* glimpsed.
3	8 50	115 191	$=h$	12·3	12·3	$g=f+6$. $h-5$ (11·8 11·8). Light of *U* rather unsteady. In the mean about equal to *h*. At times slightly brighter? High wind, poor definition, clear sky.
5	9 10	110 191	$k+3$; $l-1$ ...	13·6 13·6	13·6	At times $=l$. At times a tenth or two brighter. Light of *U* unsteady. $g=f+6$. $h-5$. ∴ 11·8.
Mar. 14	10 5	110	Glimpsed? ...	13·7 14	13·85	*l* glimpsed. *k* well seen. $g=h-2$.
18	10 15	115 110	... ...	14·5	14·5	*U* and comes both glimpsed, about 14·5. *l* well seen. $g=h-0-1$.

U Geminorum—continued.

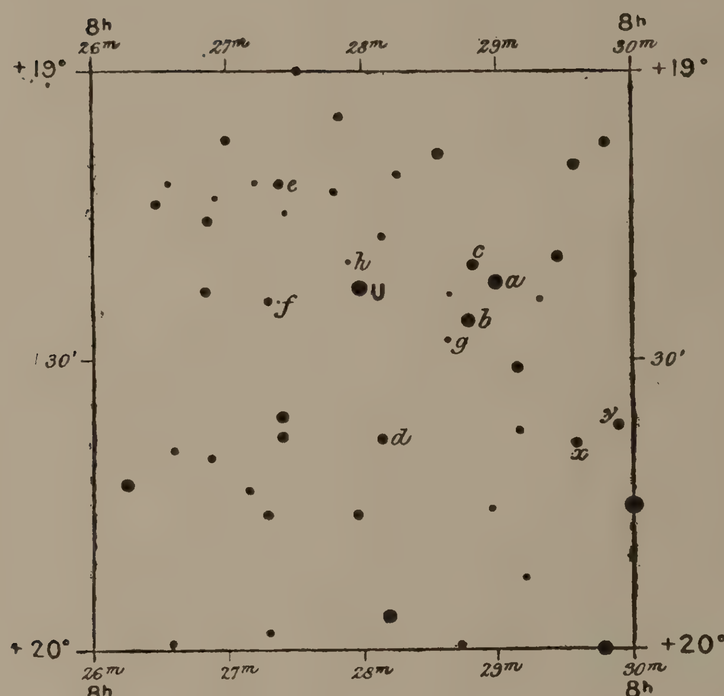
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1892.	h m					
Mar. 30	10 33	115 191	$=k$; $l-4$ ...	13·3	13·3	Light of *U* a little unsteady; looms a little large? Small star between *U* and *k* well seen with 191. $g=h$; $h+1$? Sky clear but definition not sharp.
31	8 0	70 115	$d-1$; $c+10$	10·2 10·2	10·2	White, fairly sharp. Gauged 10·2. Very white.
	10 0	110	$d-1$; $c+10$	10·2 10·2	10·2	White, fairly sharp.
Apr. 1	8 15	70	$c+7$; $d-4$...	9·9 9·9	9·9	Gauged 9·9, a few tenths brighter than last night. White, sharply defined. *d* gauged 10·3. $g=h$. I think 9·9 is a fair value for mag. of *U*. It is decidedly nearer to *d* than *c*. 9·8 would, I think, be too high. Obs. carefully made.
	10 0	70	$d-5$; $c+6$...	9·8 9·8	9·8	Perhaps 9·8 or nearly so.
2	8 15	70	$d-2$; $c+9$...	10·1 10·1	10·1	10·0 10·1 gauged. *c* gauged 9·2, *b* 9·3. *U* white. A north-east wind and stars not sharp. *U* perhaps a little "fuzzy," but hardly worse defined than *c* or *a* or *d*. (191 110) $g=h-0-1$. *U* hardly so bright as last night.
3	8 20	70 115	$d+3$; $=e$; $f-6$	10·6 10·6 10·6	10·6	White. Fairly defined.
4	8 30	110 191	Not seen; under 11·5; certainly under 11·3	...	<11·3	I see *f* and star of similar mag. S. of *k*. *g* and *h* not seen, nor *U*. Moon 1st qr., very near, and field flooded with light. Sky hazy.
5	8 20	70	Not seen ...	...	...	A hazy sky. Large halo round Moon extending to *Procyon*. *Castor* and *Pollux* just within. *a, b, c* seen. None of the stars in the *U* group visible.
6	9 0	110 191	$=k$; $k+1$?...	13·3 13·4?	13·3	Obs. difficult; moonlight, and sky not quite clear. *U* and *k* both well seen at times. *l not* seen. I think $U=k$ a fair estimate. *U cannot* be *much less*. $g=h$.
	10 10	110 191	$=k$	13·3	13·3	Observation difficult and definition very bad, but *U* and *k* both seen and I think fairly equal. Easterly wind and Moon bright.
7	9 0	110 191	Glimpsed, as also *l*	13·7?	13·7	*k* well seen. $g=h-1$. Moonlight and sky not clear. Bad definition.
Nov. 26	10 15	115	Not seen ...	Under 13·3	<13·3	*k* well seen. Not *l*.
Dec. 12	8 58	70	$c+3$; $d-8$...	9·5 9·5	9·5	Bluish white. Rather diffused disc.
	9 45	70	$c+3$; $d-8$...	9·5 9·5	9·5	9·5 gauged. With 115 bluish white. Disc not quite sharp, but definition is poor, so that there may be doubt on the point. *g* 5 or 6 tenths brighter than *h*.
13	9 0	70	$c+3$; $d-8$...	9·5 9·5	9·5	9·5 gauged. White. Much as last night.
	9 50	70 115	$c+2$; $d-9$...	9·4 9·4	9·4	9·4 gauged. White. As sharply defined as *b* or *c*. *g* intermediate in mag. between *f* and *h*. 11·8±. Obs. by Mr. J. Baxendell: "1892 Dec. 15. 8h 30m G.M.T. *b* 1 > *U. Gem.* *U* white. Sky hazy. *U* ∴ 9·4 mag."

U Geminorum—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1893. Jan. 20	h m 9 0	115	Glimpsed $=13.7\ l$	13·7	13·7	U and l glimpsed. Not very clear.
Feb. 7	8 35	115	Not seen ...	Under 13	<13	k seen at times. Hazy sky.
Mar. 25	8 33	115	Not seen ...	Under 13	<13	k glimpsed. $g=h-1$. Moon very near 1st quarter.
28	8 42	115	Not seen ...	Under 12·5	<12.5	$g=h+2$. k not seen. Moonlight and hazy sky. Obs. difficult.
29	8 55	115	Not seen ...	Under 12·5	<12.5	g and h seen. $g=h$. Moonlight and haze. Difficult obs.
31	8 30	191	Glimpsed at times	13·7	13·7	l and U glimpsed at times. k well seen. $g=h$. A milky sky, and Paschal full Moon bright.
Apr. 1	8 35	191 115	... ...	Under 13·3	<13.3	k well seen. Qu. U glimpsed at times? 13·7?? Very poor seeing.
3	8 25	191	$l+2$	13·9	13·9	k clearly seen. l well seen. U well seen. Comes between U and k glimpsed. A good observation.
4	8 45	191	$l+2$	13·9	13·9	k and l well seen. So, too, U at times.
5	8 5	110	$l+1$	13·8	13·8	l and U well seen. $g=h$?
25	8 55	70	$c+1$	9·3	9·3	White. Sharp in telescope and finder. I do not think it is quite so bright as c, at times almost equal. Moonlight. $g=h-2$.
26	8 45	70 115	$c+1$	9·3	9·3	White and sharply defined. Much as last night. $g=h+1$.
27	8 45	70 115	$=c$	9·2	9·2	Brilliant white. Sharply defined, 9·2 gauged. Rather brighter than last night? A secondary max.? $g=h+2$.
29	8 40	70 115	$c+1$	9·3	9·3	White. Sharp. $g=h+1$. U 9·3 gauged.
30	8 55	70 115	$c+3+2$; $d-8-9$	9·5 9·4 9·5 9·4	9·45	9·5 gauged. b ruddy orange tint, $=c$. $g=h+1$. U white, and with 115 sharply defined.
May 1	9 0	70	$c+2$	9·4	9·4	White, sharply defined. Obs. interrupted by clouds. A hurried observation, and perhaps a little doubtful.
3	8 45	70	$c+6$; $d-5$ ...	9·8 9·8	9·8	Twilight and hazy sky. Obs. difficult, with 115 U white and sharply defined. $g=h+4$. b ruddy $=c-1$.
5	9 0	70 115	$d+6$; $f-3$...	10·9 10·9	10·9	White, sharp. $g=h+3$.
6	9 0	115 191	$=h$	12·3	12·3	$g=h+4$. Qu. Is h rather brighter than 12·3?
7	9 50	115 191	$h+6$; $k-4$; $g+3$	12·9 12·9 12·9	12·9	$g=h+3$. Clear, but very poor definition. U rather hazy, or is this due to atmosphere? I assume h 12·3; it is possibly slightly brighter. b ruddy, $=c$.
Oct. 18	12 0	70 115	Not seen ...	Under 12·3	<12.3	Hazy and obs. very doubtful. g and h seen. k glimpsed?
Nov. 13	10 0	70 115	Not seen ...	Under 12·3??	<12.3??	A very doubtful observation.
Dec. 2	10 30	70 115	Not seen ...	Under 13·3	<13.3	Under 13·3. Under 13·7? k well seen. l seen at times. $g=h-3$.

Mr. Knott's Diagram, Epoch 1865·0.

U Cancri.



Magnitudes of Comparison Stars.

a	=	7·8	*e*	=	10·4
b	=	8·5	*f*	=	11·3
c	=	9·6	*g*	=	12·5
d	=	9·9	*h*	=	13·3

U Cancri.

THE following particulars are given in CHANDLER's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 3060 *U Cancri*, R.A. for $1900{\cdot}0 = 8^h\ 30^m\ 3^s$, Decl. $= +19°\ 14'{\cdot}4$.

Annual Variation $= +3^s{\cdot}44$ and $-0'{\cdot}20$.

R.A. for $1855{\cdot}0 = 8^h\ 27^m\ 28^s$, Decl. $= +19°\ 23'{\cdot}5$.

Redness $= 2{\cdot}3$, Max. mag. $= 8{\cdot}4 - 10{\cdot}6$. Min. $= < 14$.

Maximum : 1853 April $18 = 2397962^d$ (Julian).

Period $= 305^{d}{\cdot}0$.

(From sixteen observations of max., including observations in 1853–59, 1869–95.)

Discovered by CHACORNAC, 1853. Light-variation, occasionally at least, slow near max. 11^m pr. 3^s, $7'$ N.

U Cancri.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean. Mag.	Remarks.
1862. Feb. 8·3	h m ...	60 191	Not seen ...	Under 13	< 13	Moon too bright for faint objects.
1864. Feb. 9		60	$=b$	8·5	8·5	Near max.? Fine.
10		60	$b-1$ ...	8·4	8·4	Fine.
Mar. 12·3		60	$\frac{1}{2}(b+c)$ ...	9·05	9·05	Fine.
16		60	$b+6$; $c-5$...	9·1	9·1	
Apr. 1		60	$c+1$... ...	9·7	9·7	
2		60	$=d$	9·9	9·9	
7		60	$=d$	9·9	9·9	Clouds came up.
12		60	$e-2$... ...	10·2	10·2	
14		60	$=e$	10·4	10·4	Clear, but moonlight.
Nov. 3·3		102	Not seen ...	Under 13	< 13	
Dec. 1·5		102?	$d+2$... ...	10·1	10·1	
1865 Jan. 4·5		60	$b+3$; $c-6$...	8·8 9·0	8·9	
20·4		60	$c+4$; $=d$ ...	10·0 9·9	9·95	
28·4		60	$d+3$... ...	10·2	10·2	
Feb. 10·3		60	$d+5+7$ ...	10·4 10·6	10·5	
17·3		60	... ...	11·1 11·2	11·15	Mags. of comp. stars, d 10·0, e 10·7 est., f 11·2, g 12·2 est., h 13·5 est.
28·3		...	... ...	11·4 ±	11·4 ±	
Mar. 2·3		...	... ...	11·5 11·7	11·6	
3·3		...	... ...	11·9 12·0	11·95	
Apr. 24·4		...	Not seen ...	Under 13·5	< 13·5	
27·4		60	Not seen ...	Under 12·2	< 12·2	Hazy.
29·3		60	Not seen ...	Under 13	< 13	
May 15·4		...	Not seen ...	Under 13	< 13	
Nov. 15·5		70?	$=d$?... ...	9·9?	9·9?	Much haze. Obs. very doubtful.
Dec. 14·3		70	$e+6+7$? $=f$	11·0 11·1 11·3	11·1	Evidently past max.
18·6		70	$=f$?... ...	11·3?	11·3?	Clouds coming up.
1866. Jan. 6·4		70	$f+6+7$; $g-4$	11·9 12·0 12·1	12·0	
9·4		70	$=g$	12·5	12·5	
Feb. 17·5		70	Not seen ...	Under 13·0	< 13·0	Less than g.
Oct. 22·6		70 173	$f+5$; $g-5$...	11·8 12·0	11·9	12·0 est.
Nov. 13·5		70	Not seen ...	Under 12·0	< 12·0	
Dec. 10·5		89	Not seen ...	Under 12·5	< 12·5	Observation doubtful.
31·4		70 89	Not seen ...	Under 13 3	...	
1867. Jan. 11	11 ±	...	Not seen ...	Under 13·3	< 13·3	
Mar. 2	10 ±	89	Not seen ...	Under 13·3	< 13·3	
4	12 ±	...	Not seen ...	Under 13·3	< 13·3	

U Cancri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867. Mar. 5	h m 8 25	70	Not seen ...	Under 13·3	< 13·3	
Apr. 29	11	89	Not seen ...	Under 13	< 13	
Nov. 27	12 +	70	Not seen ...	Under 13·5	< 13·5	A cold night. Thermomr. in obs. at 12^h 30°·0. A very white frost. The night remarkably light.
Dec. 27	11 15	89	Feebly glimpsed ? ?	Under 13·5	< 13·5	
31	11 0	89	Feebly glimpsed ? ?	14?	14?	Certainly not so bright as 13·3, and I am not sure that I see it.
1868. Jan. 20	11 20	89 191	Not seen ...	Under 13·3	< 13·3	Good obs.
Feb. 6	10 45 ±	70	Not seen ...	Under	< 10	Moon too near. Field flooded with light.
11	11 30 ±	89	Not seen ...	Under 12·5	< 12·5	*g* well seen.
May 14	10 30	70	$d+8$; $=e$ ...	10·7	10·7	By mistake a comp. star "*e*" was used which had been rejected on revising the chart. The mag. of *U* may be assumed at $10\frac{3}{4}$.
18	10 20	89	$=e$?... ...	10·4 ±	10·4 ±	Hazy. Obs. doubtful.
23	10 15	70	$d+2·5$; $e-2·5$	10·15 10·15	10·15	Clear; 6^h past meridian.
1869. Jan. 3	8 50	70	Not seen ...	Under 12·5	Under 12·5	*g* seen.
5	9 0	70 89	Not seen ...	Under 13	< 13·0	*g* well seen. *h* glimpsed?
19	11 10	89	Not seen ...	Under 13·3	< 13·3	*h* seen.
Feb. 2	8 15	89	$g-0-1$ ...	12·5 12·4	12·45	
18	10 22	70	$c+4$; $d+1$; $e-4$	10·0 10·0 10·0	10·0	Fair observation.
19	7 15	70	$c+4$; $d+1$; $e-4$	10·0 10·0 10·0	10·0	
20	10 20	70	$c+3$; $=d$ ...	9·9 9·9	9·9	4-in. aperture. Flying clouds about. Moonlight.
27	7 12	70	$=c$; $d-3$ ...	9·6 9·6	9·6	Slightly ruddy?
Mar. 5	7 30	70	$c-1$... ...	9·5	9·5	Vision brilliant but confused.
Apr. 1	8 0	70	$c+2$; $d-1$ ...	9·8 9·8	9·8	Shines with a peculiar brilliancy. White? $3^{in}·7$ aperture.
4	8 45	70	$=d$	9·9	9·9	Careful comparison. Sky hazy.
8	8 30	70	$d+2$? ...	10·1?	10·1?	Doubtful observation.
30	9 0	70	$f+4$; $g-8$...	11·7 11·7	11·7	Fair observation. Defn. bad.
Dec. 24	8 24	70 89	$=c$; $d-3$ ...	9·6 9·6	9·6	Bluish-white, with a rather large disc.
1870. Apr. 2	8 7	89	Glimpsed ...	...	13·5 est.	
1871. Jan. 12	8 50	70	12·3 est. ...	...	12·3 est.	Rather > *g*.
Feb. 8	8 0	89	Very feebly glimpsed	...	13·5?	*h* glimpsed. *g* well seen.
18	8 55	70 89	Not seen ...	Below 12 mag. certainly	< 12	*g* glimpsed at times. Hazy. S.W. wind and flying clouds. Qu. Auroral clouds? The sky seems *light*.

U Cancri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871. Feb. 23	h m 7 15	153	Not seen ...	Under 13·3	< 13·3	*h* seen.
Mar. 13	10 20	70	Not seen ...	Under 13·3	< 13·3	Clear sky.
24	8 50	70	Not seen ...	Under 13 3	< 13·3	*g* and *h* seen. *g well seen.*
1872. Jan. 6	10 10	115	Not seen ...	Under 13	< 13	*h* glimpsed. *g* well seen.
Feb. 8	10 5	115	Not seen ...	Under $11\frac{1}{2}$	< $11\frac{1}{2}$	Hazy.
Mar. 5	9 0	70 191	Feebly glimpsed ? ?	Not > *h* 13·3	Not > 13·3	
Apr. 10	9 15	70 156	Not seen ...	Under 12·5	< 12·5	*g* seen.
13	8 45	156	Not seen ...	Under 13·3	< 13·3	*g* well seen. *h* glimpsed.
Dec. 7	11 40	115	Not seen ...	Under 13	< 13	*g* seen. *h* glimpsed.
1876. Dec. 22	11 0	70 89	Not seen ...	Under 12·5	< 12·5	*g* seen.
1877. Jan. 17	12 15	89	Not seen ...	Under 13	< 13	*g* and *h* seen.
25	11 40	115	Not seen ...	Under 12·5	< 12·5	*g* well seen.
Feb. 16	11 10	115	Not seen ...	Under 13·3	< 13·3	*h* seen.
Mar. 8	8 45	70	Not seen ...	Under 13·3	< 13·3	*h* seen.
21	11 15	70 115	Not seen ...	Under 12·5	< 12·5	*g* glimpsed. Moonlight and haze.
Dec. 6	12 20	89	Not seen ...	Under 12·5	< 12·5	*g* well seen. *h* not seen.
27	9 0	115	Not seen ...	Under $13\frac{1}{2}$	< 13·5	*h* glimpsed, so *g*, but, query, is it so bright as $12\frac{1}{2}$ mag.? I think not.
1878. Mar. 15	9 0	115	... ...	...	12 ±	*f* 11·3 well seen. *U* (?) seen, est. 12 ±. *g* occasionally glimpsed. Moon bright and near.
25	9 0	70	*f*+2; *g*−10	11·5 11·5	11·5	Well seen. 11 12 mag. est.
Apr. 3	8 45	70	*d*+2; *e*−3; *c*+5	10·1 10·1 10·1	10·1	Light estimates difficult from "*flaring*" of stars. A clear sky.
22	12 5	70	*b*+6; *c*−5...	9·1 9·1	9·1	A doubtful observation. Clouds. White.
25	10 30	70	*b*+10; *c*−1; *d*−4	9·5 9·5 9·5	9·5	White. Definition poor. Wind rather high. $9\frac{1}{2}$ mag. est.
26	11 20	70	*b*+8; *c*−3...	9·3 9·3	9·3	Clear, but bad definition. Wind N.E. and rather high.
May 1	10 40	70	*b*+6; *c*−5...	9·1 9·1	9·1	Obs. interrupted by clouds.
11	10 10	70 115	*b*+11; =*c*; *d*−3; *e*−8	9·6 9·6 9·6 9·6	9·6	Moonlight. Fair observation.
20	10 50	70	*c*+3; =*d*?...	9·9 9·9	9·9	A very doubtful observation. *U* 6ʰ past meridian and among clouds. I think I may say it is most certainly some few tenths less than *c*.
21	9 50	70 115	*d*+3; *e*−2...	10·2 10·2	10·2	$5\frac{1}{4}$ʰ past meridian. Clear, but definition poor.
25	10 20	70 115	*c*+4; *f*−5 ...	10·8 10·8	10·8	A bright 11 mag. est. 6ʰ past meridian
1879. Mar. 6	7 30	115	*d*+6; *e*+1; *f*−8	10·5 10·5 10·5	10·5	Moon near and obs. rather uncertain.

U Cancri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1879. Mar. 13	h m 8 45	70	$d+2$; $e-3$; $c+5$	10·1 10·1 10·1	10·1	Clear. Fair observation.
29	10 10	70 115	$d+3$; $e-2$?	10·2 10·2	10·2	Obs. a little doubtful. Abt. midway in mag. between c and f ∴ = 10·4 ±.
Apr. 10	10 35	70 115	$e+6$; $f-3$ ...	11·0 11·0	11·0	Clear sky. Fair obs.
May 2	10 30	89	$f+2$; $g-10$; $e+11$	11·5 11·5 11·5	11·5	Bad definition. Bright moonlight.
Dec. 10	11 20	70	$c+0+1$; $d-2$	9·6 9·7 9·7	9·7	*U* slight orange tint.
16	10 5	70	$b+1$; $c-10$; $d-12$	8·6 8·6 8·7	8·6	Orange tint.
29	10 5	70	$=b$	8·5	8·5	Careful estimate with full aperture. 4½ and 3 inches. *Not less* than *b*. Orange tint, clear and decided. Moon (near full) bright and near.
1880. Jan. 2	9 0	70	$a+6$; $b-1$ ...	8·4 8·4	8·4	Ruddy orange. Good observation.
3	9 10	70	$a+5$; $b-2$ ...	8·3 8·3	8·3	Orange tint. Decidedly greater than *b*. So in finder (2 inch).
12	11 25	70	$a+6+7$; $b-0-1$; $a+6$; $b-1$	8·4 8·5 8·5 8·4 8·4 8·4	8·4	Ruddy orange. Not *less* than *b*. So in finder. I think $b-1$ is a fair estimate.
19	10 30	70	$b-1$... ...	8·4	8·4	Orange tint. *Certainly not less* than *b*. So, too, in finder.
20	9 50	70	$a+7$; $=b$ ...	8·5 8·5	8·5	Ruddy orange. Not greater than *b*. On careful comparison in telescope and in *finder* I think the two stars are equal.
26	8 50	70	$=b$	8·5	8·5	Ruddy orange. Moon full and near.
29	9 5	70	$b+0+1$? ...	8·5 8·6	8·55	Orange tint.
30	10 10	70	$b+1$... ...	8·6	8·6	Orange tint. Barely $=b$ I think.
Feb. 1	8 55	70	$b+0+1$ ...	8·5 8·6	8·55	Orange tint. In finder decidedly *not* so bright as *b*.
3	11 35	70	$b+1+2$ ...	8·6 8·7	8·65	Orange tint, decided.
4	10 50	70	$b+2$... ...	8·7	8·7	Orange tint. Gauged 8·7 8·8.
8	8 20	70	$b+4$; $c-7$ ...	8·9 8·9	8·9	Ruddy orange.
11	10 15	115	$b+7$; $c-4$ ...	9·2 9·2	9·2	Ruddy orange tint.
Mar. 13	9 5	70	$f+3$; $g-9$ ...	11·6 11·6	11·6	11½ mag. est.
25	8 55	115	$f+7$; $g-5$ ...	12·0 12·0	12·0	Abt. 12 mag. est.
Dec. 25	11 25	70	$f+4$; $g-8$ ...	11·7 11·7	11·7	A bright 12 mag.
1881. Jan. 3	9 40	115	$f+6$; $g-6$ ...	11·9 11·9	11·9	Qu. fainter than it was?
Feb. 15	8 55	115	Not seen ...	Under 12	< 12	*f* and *g* well seen.
1882. Jan. 7	9 50	115	Not seen. Less than *f*	Less than 11·3	< 11·3	Moon bright and near.
Feb. 11	10 30	70	Not seen ...	Under 11·5	< 11·5	Certainly under 11·5. *f* well seen. *g* not seen.
15	10 0	115	Glimpsed? ...	13·5 ? ±	13·5 ±	A little doubtful.

U Cancri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag	Remarks.
1882.	h m					
Mar. 15	9 5	115	Not seen ...	Under 13	< 13	*h* seen.
22	9 0	70	Not seen ...	Under $12\frac{1}{2}$	< $12\frac{1}{2}$	*g* well seen.
Apr. 4	9 5	115	Not seen ...	Under $12\frac{1}{2}$	< $12\frac{1}{2}$	Clear sky, but moonlight.
6	8 55	115	$h+4$... ...	13·7	13·7	*h* seen. *U* glimpsed at times.
20	9 5	70	Not seen ...	Under 13·5	< 13·5	*h* seen.
May 20	10 0	115	Not seen ...	Under 12	< 12	*f* well seen. *g* glimpsed
1883.						
Jan. 5	10 35	110	Not seen ...	Under 12·5	< 12·5	*g* seen.
26	8 55	110	Not seen ...	Under 12	< 12	*g* seen. A gale.
30	10 40	110	Not seen ...	Under 12·5	< 12·5	*g* well seen.
Feb. 3	9 0	110	Not seen ...	Under 13·3	< 13·3	*g* and *h* well seen.
16	10 0	110	Not seen ...	Under $12\frac{1}{2}$	< 12·5	*g* seen.
23	8 15	110	Not seen ...	Under 12·5	< 12·5	*g* seen.
24	8 10	110	Glimpsed? ...	13·7 ? ?	13·7 ? ?	If seen, not > 13·5 certainly. *h* seen well.
Mar. 16	9 0	70	Not seen ...	Under 11·3	< 11·3	Among clouds. *f* well seen. *g* not seen.
23	8 35	110	Not seen ...	Under 12·5	< 12·5	Bright moonlight. *g* well seen.
30	8 50	110	Not seen ...	Under 13	< 13	
Apr. 4	10 6	70	Not seen ...	Under 12·5	< 12·5	*g* well seen.
7	9 5	70	$=h$	13·3	13·3	Both *U* and *h* visible.
25	10 7	70	$f+6$; $g-6$...	11·9 11·9	11·9	
May 7	9 55	70	$=d$	9·9	9·9	10 ± est.
June 1	10 15	115	$d+3$; $e-2$...	10·2 10·2	10·2	Obs. difficult. Stars low.
1884.						
Jan. 24	8 30	115	$f+4$; $g-8$...	11·7 11·7	11·7	Abt. $11\frac{3}{4}$ 12 est.?
Feb. 2	8 47	70 115	$f-0-1$ ...	11·3 11·2	11·25	
6	8 10	115	$e+6$; $f-3$...	11·0 11·0	11·0	
11	8 55	70	$c+3$; $=d$; $e-5$	9·9 9·9 9·9	9·9	Bright moonlight, but fairly clear.
25	7 35	70	$a+10$; $d-11$; $b+3$	8·8 8·8 8·8	8·8	Ruddy. Vision confused.
29	7 35	70	$b+1$... ...	8·6	8·6	Ruddy tint.
Mar. 5	8 30	70	$b+0+1$ ...	8·5 8·6	8·55	8·5 8·6 gauged. Ruddy.
15	8 15	70	$b+0+1$ ...	8·5 8·6	8·55	Ruddy. About equal to *b* in large telescope. Barely equal in finder.
20	7 40	70	$b+3+2$; $c-8-9$	8·8 8·7 8·8 8·7	8·75	Ruddy.
Apr. 8	10 15	70 115	$c+2$; $d-1$...	9·8 9·8	9·8	A very hazy sky. Moon near full.
16	8 33	70	$d+7$; $e+2$; $f-7$	10·6 10·6 10·6	10·6	$10\frac{1}{2}$ est.
21	8 33	70 115	$e+6$; $f-3$...	11·0 11·0	11·0	About 11 mag. est.
Dec. 9	10 10	115	$e+7$; $f-2$...	11·1 11·1	11·1	
15	8 53	70	$e+6$; $f-3$...	11·0 11·0	11·0	
17	9 3	70	$e+3$; $f-6$...	10·7 10·7	10·7	

U Cancri—continued.

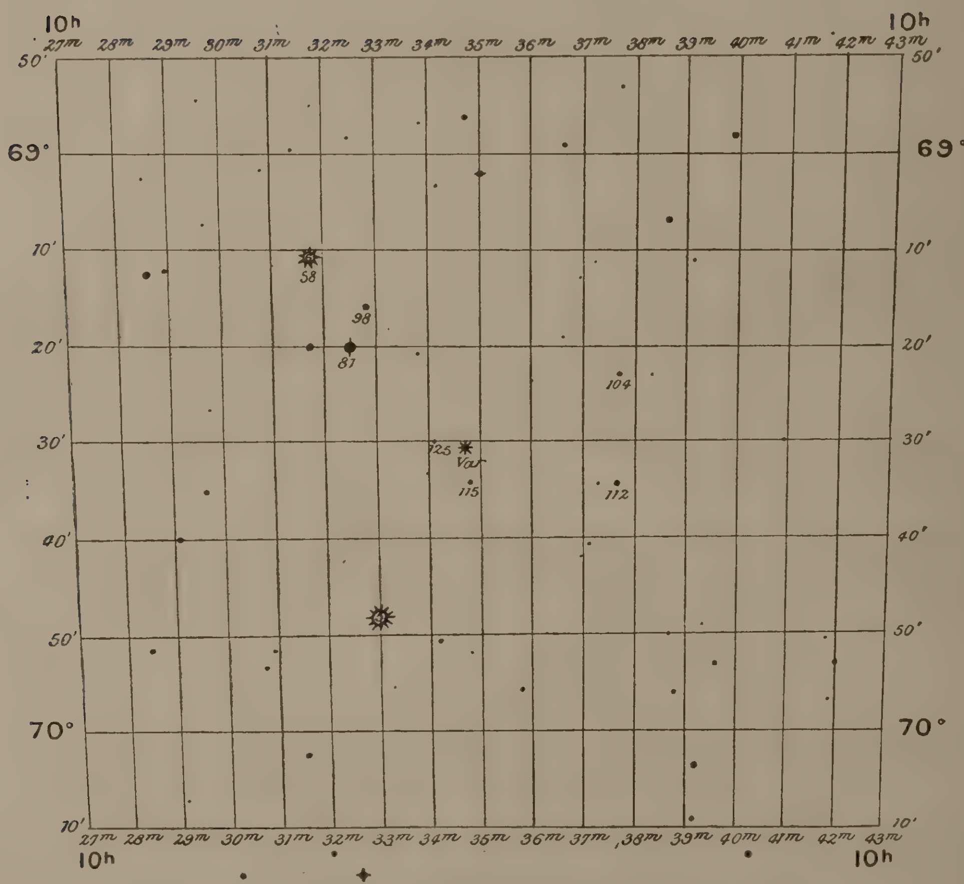
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885. Jan. 6	h m 9 0	70 115	$e+3$; $f-6$...	10·7 10·7	10·7	Rather hazy sky.
7	8 55	70	$e+2+3$; $f-7-6$	10·6 10·7 10·6 10·7	10·65	
20	9 30	70 115	$e+5$; $f-4$...	10·9 10·9	10·9	Between *e* and *f*. Nearer to *f*? Past max.? Certainly several tenths less than *e*. *f* has a small star preceding.
Feb. 5	8 6	70 115	$e+8$; $f-0-1$	11·2 11·3 11·2	11·2	Observation troublesome from occasional haze.
18	9 0	115	$f+6$; $g-6$...	11·9 11·9	11·9	
20	10 20	...	$f+6$; $g-6$...	11·9 11·9	11·9	Not changed since last observed? 12 mag. est.
Mar. 7	9 40	110	$=g$	12·5	12·5	
1886. Dec. 7	12 45	70 115	Not seen ...	Under 12	< 12	*g* seen at times. Clouds coming up.
16	10 20	115	Not seen ...	Under 12½	< 12·5	*g* seen. *h* not seen.
1887. Jan. 1	8 55	70	Not seen ...	Under 13?	< 13?	*g* well seen. *h* not seen.
25	8 50	115	Not seen ...	Under 12¾	< 12¾	*g* seen. *h* not seen.
Feb. 1	10 5	115	Not seen ...	Under 12½	< 12·5	*g* seen.
12	10 15	115	Not seen ...	Under 13·5	< 13·5	*g* and *h* seen. Qu. *U* feebly suspected at times?
15	8 50	115 110 191	Not seen. Or glimpsed?	13·6?	13·6?	*h* seen.
17	8 20	115	Not seen ...	Under 13·3	< 13·3	*h* well seen.
25	8 30	115	Not seen ...	Under 13·3	< 13·3	*h* glimpsed at times. Rather hazy.
26	7 55	115	Not seen ...	Under 13·3	< 13·3	*h* well seen, as also *h* and minute speck s.p. *b*.
28	8 5	70 115 191	Not seen ...	Under 13·3	< 13·3	*h* seen well.
Mar. 12	8 35	...	Glimpsed at times?	13·7?	13·7?	*h* well seen. *U*, if seen, not more than 13·7.
16	8 30	70 115	Glimpsed? ...	13·7?	13·7?	*h* well seen.
18	9 45	115	Not seen ...	Under 13·3	< 13·3	*h* well seen.
25	10 5	115	Not seen ...	Under 13	< 13	*g* well seen. *h* glimpsed. Very bad definition.
Apr. 8	8 47	115	Not seen ...	Under 12½ 13	< 12½ 13	*g* well seen. Paschal Moon bright.
11	9 0	115	Not seen ...	Under 13·3	< 13·3	*h* seen.
14	9 55	115	Not seen ...	Under 13·3	< 13·3	*h* seen.
16	9 0	115	Not seen ...	Under 13·5	< 13·5	*h* well seen.
30	9 50	115	Not seen ...	Under 12·5	< 12·5	*g* seen. Moon near and hazy.
May 10	10 17	115	Not seen ...	Under 12·5?	< 12·5?	*g* seen. Stars low and sky hazy.
1888. Jan. 9	12 10	115	Not seen ...	Under 13	< 13	*g* seen. *h* glimpsed?
18	8 58	115	Not seen ...	Under 13·3	< 13·3	*h* seen.
Mar. 1	8 17	115	$h+2$... ...	13·5	13·5	
5	8 0	115	$=h$	13·3	13·3	
21	7 40	70 115	$f+6$; $g-6$...	11·9 11·9	11·9	Moonlight, but stars well seen.

U Cancri—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1888.	h m					
Apr. 11	11 45	70	$=c$; $d-3$ ...	9·6 9·6	9·6	Doubtful obs. Cloudy. Bad defn. Half a gale blowing.
14	9 10	70	$b+1+2$; $c-9$	8·6 8·7 8·7	8·7	Ruddy slightly.
26	10 10	70	$b+1+0$; $c-10$	8·6 8·5 8·6	8·6	Ruddy.
30	8 50	70	$a+7$; $=b$; $c-11$	8·5 8·5 8·5	8·5	Ruddy.
May 3	10 5	70	$b+0+1$ ...	8·5 8·6	8·55	Ruddy. 8·6 gauged.
7	9 55	70	$b+0+1$ ...	8·5 8·6	8·55	Ruddy.
10	9 46	70	$b+0+1$ ...	8·5 8·6	8·55	Ruddy.
23	9 50	70	$b+5$; $c-6$...	9·0 9·0	9·0	Light and bad definition.
25	10 15	70	$b+5$; $c-6$...	9·0 9·0	9·0	
Dec. 26	10 5	115	Not seen ...	Under 12	<12	*g* seen at times.
1889. Jan. 27	8 5	70 115	$g+0+2$ ...	12·5 12·7	12·6	*h* and faint star between *c* and *b* not seen.
29	8 25	115	$f+6$; $g-6$...	11·9 11·9	11·9	Sky rather hazy. *h* not seen.
Feb. 2	9 0	70	$=f$; $e+9$ ...	11·3 11·3	11·3	
4	9 10	115	$=f$	11·3	11·3	*h* seen at times.
21	8 10	70	$e+5$; $f-4$...	10·9 10·9	10·9	
Mar. 6	8 35	70	$f-3$; $e+6$...	11·0 11·0	11·0	Hardly so bright as when last seen?
Apr. 11	8 40	115	$f+10$; $g-2$	12·3 12·3	12·3	Sky illumined by Moon.
22	8 55	115	... ...	13±	13±	Between *g* and *h*, which are both visible.
1890. Mar. 12	8 50	115	$g+2$; $h-6$...	12·7 12·7	12·7	
15	7 45	115	$g+2$; $h-6$...	12·7 12·7	12·7	
31	8 25	115	Not seen ...	Under 12½	$<12·5$	*g* glimpsed. Moonlight and haze.
Apr. 22	8 48	115	Not seen ...	Under 13	$<13·0$	
Nov. 11	12 45	70	$c+2$; $d-1$...	9·8 9·8	9·8	Ruddy.
Dec. 12	10 27	70	$=f$	11·3	11·3	
1892. Jan. 4	10 18	115	Not seen ...	Under 12	<12	*g* seen fairly.
Feb. 25	10 5	115	Not seen ...	Under 13·3	$<13·3$	*h* well seen.
Mar. 19	9 47	115	Not seen ...	Under 13·3	$<13·3$	*h* seen. *g* brightly seen.
31	10 5	110	Glimpsed? ...	13·6	13·6	*h* well seen.
Apr. 19	9 40	115	Not seen ...	Under 12·5	$<12·5$	*g* seen. Sky not clear.
1893. Mar. 31	8 41	70 115	$e+8$; $f-1$...	11·2 11·2	11·2	
Apr. 3	8 32	70	$e+7$; $f-2$...	11·1 11·1	11·1	Rather brighter than on Mar. 31?
5	8 14	70	$e+5$; $f-4$...	10·9 10·9	10·9	
21	9 0	70	$c-2-1$ ...	9·4 9·5	9·45	Ruddy. Obs. difficult. Haze and Moon.
25	8 35	70	$b+7$; $c-4$...	9·2 9·2	9·2	Ruddy?
27	9 10	70	$c-3$... ...	9·3	9·3	Ruddy. Obs. difficult in moonlight.
29	9 50	70	$b+6$; $c-5$...	9·1 9·1	9·1	
May 3	8 57	70	$b+4$; $c-7$...	8·9 8·9	8·9	Ruddy. Haze. Obs. difficult.
6	9 12	70	$b+5$; $c-6$...	9·0 9·0	9·0	Ruddy.

Mr. Knott's Diagram, Epoch 1860 ?

R Ursæ Majoris.



[The numbers assigned in the above diagram are ten times the assumed magnitudes of stars. Two stars used by Mr. Knott from 1885 onwards, and denoted by him l and m, with assumed magnitudes 12·6 and 13·3, cannot be identified from any of his notes.]

R Ursæ Majoris.

The following particulars are given in Chandler's Third Catalogue of Variable Stars (*Astron. Journal*, No. 379):—

No. 3825 *R Ursæ Majoris* R.A. for 1900·0 = $10^h\ 37^m\ 34^s$, Decl. = $+69°\ 18'·0$.

Annual Variation = $+4^s·32$ and $-0'·31$.

R.A. for 1855·0 = $10^h\ 34^m\ 19^s$, Decl. = $+69°\ 32'·1$.

Redness = 1·6, Max. magnit. = 6·0 − 8·2, Min. = 12·6 − 13·2.

$M - m = 107^d$.

Maximum: 1853 April 7 = $2397951^d·2$ (Julian).

Periodicity represented by $302^d·1$ E. + 15^d sin (10° E. + 190°) where E is the number of periods.

(From forty-one observations of Max. and seventeen of Min., including observations in 1843–95.)

Discovered by Pogson, 1853. Light curve very variable.

R Ursæ Majoris.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865. Mar. 3·5		60	... ...	11·4 est.	11·4 est.	
Apr. 22·3		60	... ...	13 ±	13 ±	
24·4		...	... ...	13	13	
May 22·5		60	... ...	12·5	12·5	
25·5		60	... ...	12·5	12·5	
July 19·5		60	98 − 3 ; 81 + 12	9·5 9·3	9·4	
28·5		60	81 − 2 ...	7·9	7·9	
Aug. 9·4		60	81 − 10 ...	7·1	7·1	In brightness abt. midway between 58 and 81.
14·4		60	58 + 11 ; 81 − 11	6·9 7·0	6·95	
24·4		60	> 81 < 58. Considerably nearer to 58	6·5 ?	6·5 ?	Ruddy.
Sept. 7·4		...	58 + 8 ; 81 − 15	6·6 6·6	6·6	6·7 gauged. Ruddy.
18·3		60	58 + 13 ; 81 − 10	7·1 7·1	7·1	
Oct. 3·4		70	58 + 9 ...	6·7	6·7	Mr. Birt's estimate was R = 58 + (81 − 58) × 0·4 = 6·7.
Nov. 1·3		60	81 + 2 ...	8·3	8·3	Ruddy.
3·4		70	81 + 0 + 1 ...	8·1 8·2	8·15	Ruddy. In finder (2 inch ap.). Decidedly < 81.
13·3		60	81 + 9 ; 98 − 8	9·0 9·0	9·0	Ruddy.
18·3		70	81 + 6 ; 98 − 10	8·7 8·8	8·75	Decidedly red.
29·3		70	98 − 1 ...	9·7	9·7	Ruddy.
Dec. 14·3		70 ?	104 + 3 ; 115 − 7 − 8	10·7 10·8 10·7	10·7	Red. Among clouds.
30·3		70	104 + 7 ; 115 − 4	11·1 11·1	11·1	11 mag. estimated.
1866. Jan. 6·5		70	112 ; 115 − 2	11·2 11·3	11·25	
12·3		70	115	11·5	11·5	
16·4		70	... ...	12·0 ?	12·0 ?	
23·4		70	... ...	12·5 ±	12·5 ±	
Feb. 3·4		70	... ...	12·8 13·0	12·9	
17·4		70	125 + 5 ...	13·0	13·0	
Mar. 10·3		...	125 + 5 + 7 ...	13·0 13·2	13·1	13 or 13·2 est.
Apr. 13·4		70	125 + 5 ...	13·0	13·0	
25·3		70	125 + 5 ...	13·0	13·0	13·0 est.
May 16·4		70	115 + 6 ; 125 − 4	12·1 12·1	12·1	
June 7·8		70	81 + 8 ; 98 − 8	8·9 9·0	8·95	Decidedly ruddy.
16·4		60	81 + 0 + 1 + 2	8·1 8·2 8·3	8·2	Ruddy.
22·4		70	= 81... ...	8·1	8·1	Ruddy orange.
26·4		70	= 81... ...	8·1	8·1	Slightly ruddy.
July 9·4		70	81 − 3 − 4 ...	7·8 7·7	7·75	Ruddy.
14·4		70	81 − 3 ...	7·8	7·8	Ruddy.

R Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866.	h m					
July 20·4		70	81 − 5 ...	7·6	7·6	Fine red.
Aug. 3·5		70	81 − 3 − 4 ...	7·8 7·7	7·75	
16·4		70	= 81... ...	8·1	8·1	Ruddy.
31·5		70	= 98 ; 98 − 1	9·8 9·7	9·75	
Sept. 14·3		60	98 + 5 ; 104 − 1	10·3 10·3	10·3	Ruddy.
Oct. 8·3		70	112 + 2 ; 115 − 1	11·4 11·4	11·4	
22·3		70	115 + 5 ; 125 − 5	12·0 12·0	12·0	Moonlight.
Nov. 13·3		70	12·7	12·7	12·7	
27·3		70	... ...	13·0 13·2	13·1	A glimpse object. Hazy.
Dec. 7·3		70	... ...	13·3 est.	13·3	
19·3		70 89	Glimpsed ? ...	13·2 ?	13·2 ?	Moonlight.
1867. Jan. 4·3		70	[104 + 6 ; 112 − 2]	[11·0 11·0]	...	It would seem that this obs. does not refer to *R*.
11	11 20	70 89	... ...	13·5 ?	13·5 ?	Obs. doubtful. Identification of star questionable.
Feb. 6	11 30	70 89	125 + 5 ...	13·0	13·0	
14	8 ±	70 89	125 + 5 ...	13·0	13·0	
Mar. 2	10 +	70	115 + 3 + 4 ; 125 − 7 − 6	11·8 11·9 11·8 11·9	11·85	
Apr. 29	11 −	70	81 − 7 ; 58 + 14 ?	7·4 7·2	7·3	Yellow.
May 21	11 30	70	81 − 5 − 6 ...	7·6 7·5	7·55	7·5 ± est. Of a ruddy cast.
June 4	10 55	70	81 − 5 ...	7·6	7·6	Decidedly ruddy.
26	11 30	70	81 + 6 ; 98 − 11	8·7 8·7	8·7	Ruddy. Mrs. Knott's obs. "Between 81 and 98, but decidedly nearer to 81 in brightness. Ruddy."
July 5	11 30	70	81 + 10 ; 98 − 7	9·1 9·1	9·1	Dull red.
9	11 40	70	81 + 12 ; 98 − 5	9·3 9·3	9·3	Dull ruddy. 5 inch aperture.
16	11 30	70	81 + 15 ; 98 − 2	9·6 9·6	9·6	Dull purplish red.
27	10 +	70	98 + 5 ; 104 − 1	10·3 10·3	10·3	
Aug. 2	11 −	70	98 + 6 + 7 ; 104 + 0 + 1	10·4 10·5 10·4 10·5	10·45	Full aperture.
9	11 15	70	104 + 5 ; 112 − 3	10·9 10·9	10·9	Decidedly ruddy. 5 inch aperture.
20	9 0	70	104 + 6 ; 115 − 5	11·0 11·0	11·0	11 mag. est. 5 inch aperture.
Sept. 5	8 50 ±	89	12·0 est. ...	12·0 est.	12·0 est.	Some tenths < 115.
10	10 30 ±	89	115 + 5 ; 125 − 5	12·0 12·0	12·0	Full aperture. 12^h past meridian.
Oct. 5	7 +	70 89	Not seen ...	Below 10 mag.	...	Haze and cloud troublesome.
Nov. 2	9 +	89	13·5 est. ...	13·5 ±	13·5 ±	Fairly seen.
Dec. 7	10 40 ±	70	... ...	[11·2 ?]	[11·2 ?]	Telescope field so light with Moon that identity a little uncertain.
26	7 50	70	125 + 6 + 7 ...	13·1 13·2	13·15	The observation of Dec. 7 probably referred to 115.
1868. Jan. 20	11 30	60	11·0	11·0	11·0	Obs. rather doubtful. Hazy. A white frost. Wind N.E.

R Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1868.	h m					
Feb. 6	11 0	70	=81 ...	8·1	8·1	Slightly ruddy.
11	11 50±	70	81+0+1; 81+2?	8·1 8·2 8·3?	8·2	Decidedly ruddy orange.
Apr. 2	9 5	70	81−3 ...	7·8	7·8	Golden, with ruddy cast.
23	9 0	70	81+8; 98−9	8·9 8·9	8·9	Obs. doubtful in haze.
May 14	12 0	70	98+2; 104−4	10·0 10·0	10·0	Slight ruddy cast ??
27	10 45	70	104+2; 112−6	10·6 10·6	10·6	Slightly red ?
June 5	11 15	70	104+2; 112−6	10·6 10·6	10·6	
15	10 35	70	=112; 115−3	11·2 11·2	11·2	Clear.
29	11 25	89	115+5; 125−5	12·0 12·0	12·0	Observation a little doubtful.
July 20	10 20	70	... ...	13·0	13·0	Careful comparison with 115 and 125.
Aug. 3	11 0±	89	Not seen? ...	Under 11	<11·0	Lost in bright moonlight and flying haze.
Sept. 5	9 0	89 191	Feebly glimpsed?	13·5?	13·5±	Moon rising.
30	7 45	89	Not seen ...	Under 11	<11·0	A moist atmosphere, and Moon up, nearly full.
Oct. 7	8 30	89	Glimpsed? ...	13·5?	13·5±	I am doubtful of the identity of the object. 11ʰ past meridian.
Nov. 2	11 15	70	125+5 ...	13·0	13·0	Moonlight. Star well seen.
Dec. 19	8 45	70	81−1−2 ...	8·0 7·9	7·95	Clear orange yellow.
1869.						
Jan. 5	9 10	70	81−3 ...	7·8	7·8	Orange yellow.
19	12 35	70	81−5 ...	7·6	7·6	$7\frac{1}{2}$ $7\frac{3}{4}$ est. Coppery red.
Feb. 2	8 45	70	81−3? ...	7·8	7·8	Ruddy orange.
19	7 30	70	81+4+3; 98−13−14	8·5 8·4 8·5 8·4	8·45	Ruddy decidedly. Coppery red.
27	9 0	70	81+5; 98−12	8·6 8·6	8·6	Orange red.
Apr. 1	9 10	70	98+2; 104−4	10·0 10·0	10·0	Sky rather hazy.
June 15	11 45	70	125+7 ...	13·2	13·2	$13\frac{1}{4}$ $13\frac{1}{2}$ est. Careful observation.
July 10	11 25	89 191	A glimpse object	13·5±	13·5±	115 and 125 well seen.
Aug. 6	11 20	89	Glimpsed? ...	13·5?	13·5?	Doubtful observation.
26	10 30	89	125+2 ...	12·7	12·7	Clear. 10ʰ past meridian.
Sept. 21	8 35	70	98+2; 104−4	10·0 10·0	10·0	10 mag. est. Moonlight and among clouds. Fair obs. Orange tint.
Oct. 11	8 10	70	81−6 ...	7·5	7·5	Coppery red. Clear.
26	7 21	70	58+13; 81−10	7·1 7·1	7·1	Clear yellow.
Dec. 24	7 43	70	=81 ...	8·1	8·1	Coppery red.
1870.						
Apr. 2	8 30	70 89	115+6; 125−4	12·1 12·1	12·1	Well seen.
May 7	11 0	70	12?	...	12?	A doubtful observation.
June 6	11 40	89	=125; =125+?	12·5 12·5+	12·5	Pretty good observation.

R Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1870. Oct. 26	h m 7 8	70	81+3+4; 98−13	8·4 8·5 8·5	8·5	Decidedly ruddy. 11h past meridian.
1871. Jan. 12	8 30	70	=115 ...	11·5	11·5	Good observation.
Feb. 8	8 40	70	... ...	13·0 13·3	13·15	By comparison with 115 and 125.
Mar. 1	9 0	70	Not seen ...	Under 13	< 13	125 well seen.
18	9 30	70	Glimpsed? ...	...	13·5	
May 17	12 30	70	=125 ...	12·5	12·5	Perhaps slightly greater than 12·5.
June 28	11 20	70	81−3−4 ...	7·8 7·7	7·75	About $7\frac{3}{4}$ mag. Yellow with slight orange cast.
July 22	11 43	70	=81 ...	8·1	8·1	Ruddy. In finder (2 in. ap.) hardly so bright as 81.
Aug. 15	11 30	70	81+ ...	8·1+	8·2?	Barely 8·1. Ruddy.
Sept. 11	8 27	70	81+13; 98−4	9·4 9·4	9·4	Ruddy.
Oct. 14	7 5	70	=115 ...	11·5	11·5	Clear.
Nov. 29	8 0	115	... ...	13 est.	13	Clear. Bright moonlight.
Dec. 20	12 0	115	... ...	13±	13	Obs. a little doubtful.
1872. Mar. 5	11 0	70	115+5; 125−5	12·0 12·0	12·0	
Apr. 13	11 30	70	81+2 ...	8·3	8·3	Ruddy. $8\frac{1}{4}$ est.
June 13	11 0	70	=81 ...	8·1	8·1	Slightly ruddy? Barely = 81 in finder.
Aug. 31	9 30	70	104+6; 112−2; 115−5	11·0 11·0 11·0	11·0	Clear and still.
Oct. 22	11 20	115	... ...	$12\frac{1}{2}$ 13 est.	12·75	Hazy and moonlight.
Dec. 7	11 25	70 115	125−0−3; 115+7+10	12·5 12·2 12·2 12·5	12·35	
1877. Jan. 25	12 15	70	115+5; 125−5	12·0 12·0	12·0	Well seen.
Feb. 16	7 40	70	104+6; 112−2	11·0 11·0	11·0	11 mag. est.
Mar. 21	9 0	70	81−3−5 ...	7·8 7·6	7·7	Ruddy lilac? $7\frac{1}{2}$ $7\frac{3}{4}$ est.
Apr. 10	8 45	70	58+13; 81−10	7·1 7·1	7·1	Ruddy with slight lilac tinge. Gauged 7·0 7·1 mag. Certainly brighter than 74.
25	11 30	70	58+17; 81−6	7·5 7·5	7·5	Ruddy lilac. $7\frac{1}{2}$ mag. est. Moonlight.
May 2	10 30	70	81−4 ...	7·7	7·7	Ruddy with lilac tinge
7	10 30	70	81−2 ...	7·9	7·9	Ruddy lilac.
15	10 35	70	=81 ...	8·1	8·1	Decidedly ruddy
June 9	11 0	70	81+9; 98−8	9·0 9·0	9·0	9m est. Ruddy lilac.
23	10 40	70	=98; 104−6	9·8 9·8	9·8	Ruddy lilac.
July 7	12 5	70	=104 ...	10·4	10·4	
26	10 45	70	104+8; =112; 115−3	11·2 11·2 11·2	11·2	Clear.

R Ursæ Majoris—continued.

Date of Observation	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877.	h m					
Aug. 14	10 40	70	115+5; 125−5	12·0 12·0	12·0	Fair observation.
Sept. 27	12 20	115	Glimpsed ...	13·5	13·5	115 and 125 well seen. Moonlight.
Oct. 5	11 35	70	13·5 est. ...	...	13·5 est.	About one mag. < 125.
27	11 10	115	... ...	...	13·5 est.	About one mag. less than 125.
Dec. 10	7 10	70 115	=115; 115−? =112?	11·5 11·2?	11·4	Obs. a little doubtful. 10^h from meridian. Perhaps rather brighter than 115, more nearly = 112.
27	7 45	70	81+13; 98−4; 104−10	9·4 9·4 9·4	9·4	Ruddy.
1878.						
Jan. 28	11 10	70	58+12; 81−11	7·0 7·0	7·0	Ruddy. 7 mag. est.
Feb. 14	8 58	70	58+15 81−8	7·3 7·3	7·3	Yellow with slight lilac cast.
Mar. 12	11 30	70	81+2 ...	8·3	8·3	8¼ ± est. Ruddy lilac. Close to meridian. Moonlight and slightly cloudy.
16	10 10	70	81+2 ...	8·3	8·3	Ruddy lilac.
Apr. 3	9 5	70	81+8; 98−9	8·9 8·9	8·9	Ruddy.
May 11	10 45	70	98+5; 104−1; 112−9	10·3 10·3 10·3	10·3	In clear intervals between clouds.
June 6	12 55	70	104+6; 115−5	11·0 11·0	11·0	5 and 58 clear topaz yellow.
July 13	11 50	115	Not seen ...	Under 11·5?	Under 11·5?	115 seen? A very doubtful obs. Stars lost in haze and moonlight.*
Aug. 1	12 50	115	125+10? ...	13·5?	13·5?	Faint 13¼ est. Considerably less than 125.
Oct. 12	10 45	70	104+4; 112−4	10·8 10·8	10·8	
1881.						
Mar. 22	10 0	115?	104+6; 112−2; 115−5	11·0 11·0 11·0	11·0	
1882.						
Jan. 24	10 5	70	=112 ...	11·2	11·2	
Feb. 15	10 15	70	=104 ...	10·4	10·4	
Mar. 3	8 52	70	=81... ...	8·1	8·1	8·1 gauged.
16	10 20	70	7·3 gauged ...	...	7·3	Red lilac. Fine colour.
22	8 18	70	7·0 gauged ...	...	7·0	7·0 gauged. A strongly banded spectrum.
31	9 0	70	7·1 gauged ...	...	7·1	81 gauged 8·1. Ruddy.
May 20	10 20	70	81+2 ...	8·3	8·3	8¼ est.
1883.						
Feb. 6	8 40	70	81−2 ...	7·9	7·9	Ruddy orange.
24	8 55	70	81+1 ...	8·2	8·2	Gauged 8·2.
June 1	10 23	70	=125 ...	12·5	12·5	

* In the MS. there is the following note: "Mr. Franks' star 1½ S. of 5 a little following; fine ruddy, 6½ mag. est." The star referred to is apparently one given in a MS. Catalogue of stars presented to the R.A.S. Library by Mr. Franks in 1878, described as "1° *f* PX. 126, Ru Proctor, mag. 6½ (B.A.C. 7), Fiery red, one of the finest red stars I have ever seen." To the note "Ru Proctor" in Mr. Franks' MS. is a pencil note in Mr. Knott's handwriting suggesting some confusion or mistake.

R Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884. Nov. 15	h m 9 30	70	81+9; 98−8	9·0 9·0	9·0	Fine orange red.
22	8 47	70	98−3; 81+12+14	9·5 9·3 9·5	9·45	Ruddy; a delicate tint.
28	9 5	70	=98... ...	9·8	9·8	
Dec. 4	8 53	70	=98... ...	9·8	9·8	
15	9 15	70	98+5; 104−1	10·3 10·3	10·3	
1885. Jan. 7	9 9	70	104+5; 112−3	10·9 10·9	10·9	
Feb. 5	8 0	115	125+2 ...	12·7	12·7	$12\frac{3}{4}$ 13 est. Obs. a little difficult. Haze at times.
18	10 47	115	125+5 ...	13·0	13·0	13 mag. ±
Mar. 7	8 30	115	= *m*	13·3	13·3	13 $13\frac{1}{2}$ est.
14	10 5	115	$\frac{1}{2}(l+m)$ ...	13·0	13·0	
20	9 12	115	*l*+3; *m*−4...	12·9 12·9	12·9	A high wind blowing.
30	10 12	115	*l*+4? ...	13·0	13·0?	
Apr. 18	10 40	115	115+7; *l*−4	12·2 12·2	12·2	Rather doubtful.
May 11	10 50	115	115−2 ...	11·3	11·3	Hazy sky.
29	10 15	70	=98... ...	9·8	9·8	Ruddy decidedly. A bright 10 mag. est. About 1° south of this a fine ruddy orange star, No. 324 of Gore's suspected Var. Cat. Abt. 6 mag. Hardly so bright as 58 of *R Ursæ* chart.
June 17	11 3	70	81−6; 58+17	7·5 7·5	7·5	Yellowish? Not red? Abt. $7\frac{1}{2}$ mag. est.
July 10	12 5	70	58+17; 81−6	7·5 7·5	7·5	Yellow. Slight orange?
20	10 25	70	81−6 ...	7·5	7·5	Yellow with orange tinge. $7\frac{1}{2}$ est.
Aug. 10	11 30	70	81+5 ...	8·6	8·6	8·6 gauged. (81 gauged 8·1.) *R* ruddy orange.
29	8 37	70	81+12; 98−5	9·3 9·3	9·3	Slightly ruddy.
Oct. 27	7 12	115	112+3; =115	11·5 11·5	11·5	$11\frac{1}{4}^{h}$ past meridian.
Dec. 15	10 35	115	*l*+5; *m*−2...	13·1 13·1	13·1	Obs. a little doubtful. Sky not very clear.
1886. May 15	8 30	70	58+15; 81−6	7·3 7·5	7·4	7·5 gauged. Pale yellow. Moonlight and twilight. Obs. rather doubtful.
June 1	10 40	70	81−3 ...	7·8	7·8	7·8 gauged. Pale yellow.
23	11 45	70	81+3 ...	8·4	8·4	Slightly orange tint. About $8\frac{1}{2}$.
30	11 40	70	81+9; 98−8	9·0 9·0	9·0	Orange tint.
July 5	11 30	70	98−3; 81+14	9·5 9·5	9·5	9·5 gauged. Full ruddy.
15	10 47	70	98−1; 104−7	9·7 9·7	9·7	Pale red. Clear tint.
24	11 0	70	98+2; 104−4	10·0 10·0	10·0	Ruddy.
Aug. 10	10 50	70	104+2; 110−6	10·6 10·4	10·5	
Sept. 30	7 15	115	*l*+2; *m*−5...	12·8 12·8	12·8	Obs. a little doubtful. Not quite clear. 125=115+5?

R Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1886	h m					
Nov. 16	7 40	115	$m+2$? ...	13·5?	13·5	About $13\frac{1}{2}$ mag. est.
29	7 54	115	$m+2$ ...	13·5	13·5	Clear sky.
Dec. 16	7 0	115	$m+2$ ...	13·5	13·5	l and m well seen. A good observation. (125 = 115 + 5?)
1887.						
Jan. 20	7 50	115	$l-6$; 115+5	12·0 12·0	12·0	
25	7 15	70 115	104+5; 115−6; 112−3	10·9 10·9 10·9	10·9	Sky rather hazy.
Feb. 1	9 50	70	98+4; 104−2	10·2 10·2	10·2	Ruddy. 10·3 gauged.
7	9 55	70	98−3; 81+14	9·5 9·5	9·5	Orange ruddy.
12	8 17	70	81+3 ...	8·4	8·4	8·4 gauged. Orange ruddy.
14	7 40	70	81+1+2 ...	8·2 8·3	8·25	{8·2, 8·3} gauged. Orange ruddy.
16	10 9	70	81+0+1 ...	8·1 8·2	8·15	Ruddy orange.
21	10 12	70	81−0−1 ...	8·1 8·0	8·05	Slight orange tint.
26	8 53	70	= 81... ...	8·1	8·1	8·1 gauged. Orange tint.
Mar. 1	9 55	70	= 81... ...	8·1	8·1	8·1 gauged. So too 81. R decidedly ruddy.
12	8 45	70	81+1 ...	8·2	8·2	Orange or ruddy. Gauged about 8·2. Not so bright as 81 I am pretty sure. Clouds troublesome.
16	9 0	70	81+1+2 ...	8·2 8·3	8·25	Gauged 8·3. 81 gauged 8·1. A slight orange tint.
26	8 40	70	81+3 ...	8·4	8·4	8·4 gauged. Orange ruddy.
Apr. 8	9 0	70	81+9; 98−8	9·0 9·0	9·0	Full ruddy. 9·0 gauged.
16	10 0	70	81+11; 98−6	9·2 9·2	9·2	9·2 gauged. Ruddy orange.
30	10 25	70	98−0−1 ...	9·8 9·7	9·75	Ruddy.
May 10	10 55	70	98+4? ...	10·2?	10·2?	Ruddy.
June 13	10 25	115	= 125 ± ...	12·5 ±	12·5 ±	
18	10 55	115	115+6; $l-5$	12·1 12·1	12·1	Clear. 6h past meridian.
30	11 32	115	$l-1$	12·5	12·5	Clear.
July 18	11 7	115	$l+4$; $m-3$...	13·0 13·0	13·0	A little hazy.
21	11 12	115	$l+5$; $m-2$...	13·1 13·1	13·1	125 abt. 12·0 mag.
Aug. 12	10 45	115	... ...	13 ±	13 ±	Doubtfully glimpsed. l seen. m not seen. Hazy.
22	10 30	115	= m	13·3	13·3	
Oct. 1	8 15	115	Not seen ...	Under 12	< 12	115, 125 seen. l not seen. Sky hazy and moonlight.
11	8 0	115	$m-2$ ...	13·1	13·1	Clear sky. 115, 125, l and m well seen.
19	8 20	115	$l+2$; $m-5$...	12·8 12·8	12·8	$11\frac{1}{2}$h past meridian, but clear sky.
31	7 35	115	115+6; $l-5$	12·1 12·1	12·1	Well seen, though only 30m from lower transit.
Nov. 14	8 40	70	104+6; 112−2	11·0 11·0	11·0	

R Ursæ Majoris—continued.

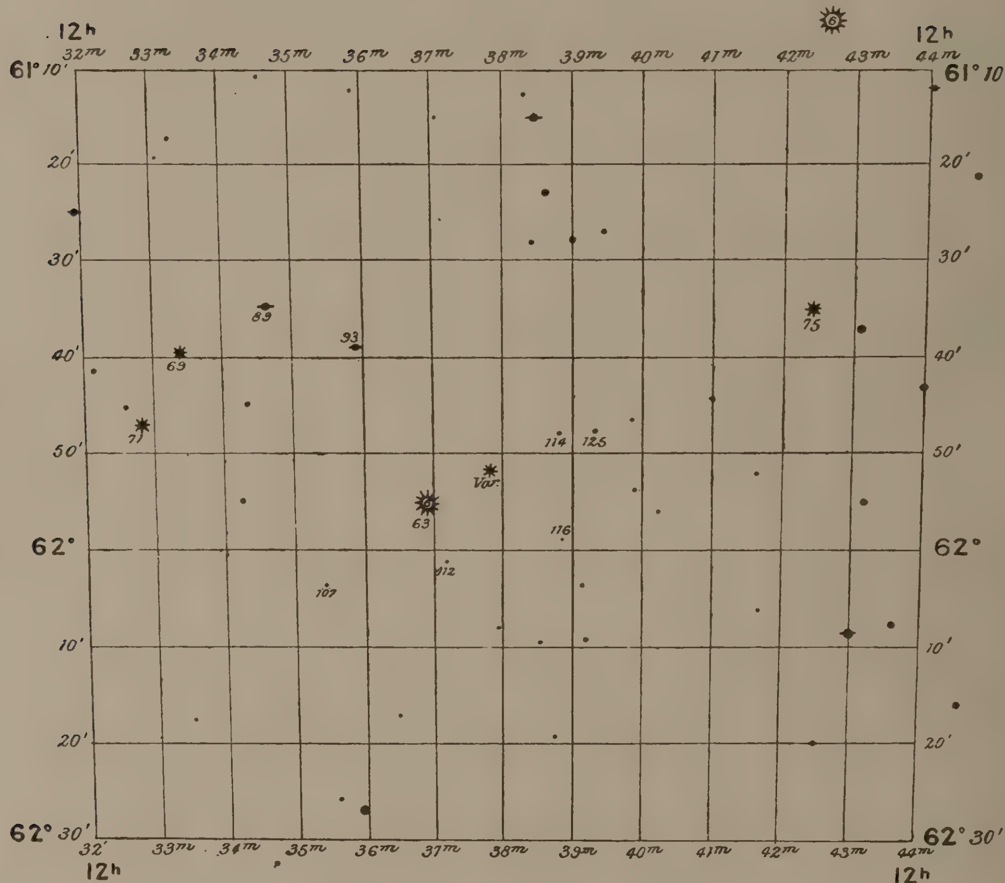
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887.	h m					
Nov. 30	7 50	70	81+5; 98−12	8·6 8·6	8·6	Orange ruddy.
Dec. 15	7 30	70	=81... ...	8·1	8·1	Coppery red.
1888.						
Jan. 9	7 45	70	81−2 ...	7·9	7·9	Yellow.
18	7 15	70	81−2 ...	7·9	7·9	Orange yellow. 7·9 8·0 gauged.
23	7 40	70	=81... ...	8·1	8·1	Orange yellow.
Mar. 1	7 17	70	81+11; 98−6	9·2 9·2	9·2	Ruddy.
21	8 30	70	=98... ...	9·8	9·8	Ruddy.
May 1	10 10	115	=115 ...	11·5	11·5	
7	10 5	70	115+2+3 ...	11·7 11·8	11·75	Not quite clear. Haze came over at 10·15.
12	9 55	115	115+5; 125−5; *l*−6	12·0 12·0 12·0	12·0	
23	10 0	115	125−2 ...	12·3	12·3	Fair obs.
Aug. 8	11 0	70	*l*+4... ...	13·0	13·0	13·0 est. Rather hazy.
Oct. 5	7 10	70	81−4 ...	7·7	7·7	Orange ruddy. Decided tint.
11	8 30	70	81−5 ...	7·6	7·6	Ruddy orange. Some tenths less than 81.
18	7 10	70	81−6 ...	7·5	7·5	About 7·5 gauged. Ruddy orange.
23	7 10	70	81−5 ...	7·6	7·6	7·5 7·6 gauged. Ruddy orange.
27	6 55	70	81−5 ...	7·6	7·6	Orange tint.
Nov. 6	6 50	70	81−2 ...	7·9	7·9	Gauged 8·0. 81 gauged 8·1. *R* full orange red.
13	7 45	70	81−4 ...	7·7	7·7	Orange ruddy.
20	8 0	70	=81 ...	8·1	8·1	Orange red.
Dec. 6	7 10	70	81+10; 98−7	9·1 9·1	9·1	9·1 9·2 gauged. Ruddy orange.
12	7 5	70	81+5 ...	8·6	8·6	Ruddy orange. 8·6 gauged.
26	8 0	70	81+15; 98−2	9·6 9·6	9·6	Orange ruddy. 9·6 9·7 gauged.
1889.						
Jan. 27	8 45	70	115−8 ...	10·7	10·7	About $10\frac{3}{4}$ est.
Feb. 2	8 22	70	104+6; 112−2	11·0 11·0	11·0	
21	8 40	70	115−2 ...	11·3	11·3	About $11\frac{1}{4}$ est.
Mar. 6	8 55	70 115	115+5; 125−5	12·0 12·0	12·0	
June 3	10 10	70	=125 ...	12·5	12·5	
Sept. 6	9 50	70	58+13; 81−10	7·1 7·1	7·1	About 7 mag. Orange yellow.
10	8 5	70	58+14; 81−9	7·2 7·2	7·2	7·2 gauged. Clear yellow. Some dark absorption bands in spectrum.
Oct. 23	7 30	70	81+10; 98−7	9·1 9·1	9·1	Ruddy orange. Rather doubtful observation. Rather cloudy.
25	7 0	70	81+8; 98−9	8·9 8·9	8·9	Ruddy.
31	7 0	70	81+10; 98−7	9·1 9·1	9·1	Ruddy. 9·2 gauged.
Nov. 12	8 40	70	98+2 ...	10·0	10·0	Ruddy.
25	8 25	70	98+6; =104	10·4 10·4	10·4	Ruddy.
30	8 37	70	=104 ...	10·4	10·4	Orange ruddy.

R Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889. Dec. 4	h m 8 32	70	= 104 ; 115 − 11	10·4 10·4	10·4	Orange ruddy.
24	8 23	70	104 + 7 ; 115 − 4	11·1 11·1	11·1	
1890. Apr. 1	9 40	115	l + 1	12·7	12·7	
22	10 5	70	l − 2 ? ...	12·4 ?	12·4 ±	
Aug. 4	10 20	70	81 + 1 ...	8·2	8·2	Orange ruddy.
8	10 10	70	81 + 4 ...	8·5	8·5	Orange tint.
18	9 30	70	81 + 8 ; 98 − 9	8·9 8·9	8·9	
23	9 45	70	81 + 11 ; 98 − 6	9·2 9·2	9·2	Ruddy.
30	8 41	70	98 − 4 ...	9·4	9·4	Orange ruddy.
Sept. 4	9 35	70	98 − 3 ...	9·5	9·5	Decidedly ruddy.
8	9 40	70	98 − 2 ...	9·6	9·6	Orange ruddy. Decided colour.
13	7 58	70	98 + 2 ...	10·0	10·0	Ruddy.
15	8 43	70	98 + 3 ; 104 − 3	10·1 10·1	10·1	Ruddy.
Oct. 25	7 47	70	= 115 ...	11·5	11·5	A rather doubtful obs. 11h 20m past meridian, and sky not very clear.
Nov. 4	7 5	115	115 + 7 ; l − 5	12·2 12·1	12·15	11½h past meridian. 125 = 11·8 ?
Dec. 9	8 20	115	m + 0 + 2 ...	13·3 13·5	13·4	
13	7 43	115	= m	13·3	13·3	
1891. Jan. 1	7 35	70 115	m + 2 ...	13·5	13·5	
Feb. 4	10 40	115	... ...	11·5	11·5	
20	8 25	70 115	... ...	...	...	Moonlight and hazy sky. Very bad for obs. Failed to see *R*. White filmy haze all over sky.
26	8 0	70 115	= m ; l + 6 ...	13·3 13·2	13·25	[Qu. Is there some error in my obs. of Feb. 4 ? !]
Mar. 3	7 53	115	l + 5 ; m − 2...	13·1 13·1	13·1	High wind. Bad definition.
27	8 30	70 115	81 + 11 ; 98 − 6	9·2 9·2	9·2	Orange red. Full coloured.
May 7	10 30	70	81 − 3 ...	7·8	7·8	Ruddy.
June 5	11 5	70	81 + 4 ...	8·5	8·5	Orange ruddy.
July 28	10 58	70	104 + 5 ; 115 − 6	10·9 10·9	10·9	
Aug. 10	10 40	70	115 − 2 ...	11·3	11·3	
Oct. 12	10 3	115	l + 4 ; m − 3...	13·0 13·0	13·0	
23	8 13	115	l + 5	13·1	13·1	Stars low. Obs. difficult.
28	7 40	115	l + 5 ; m − 2...	13·1 13·1	13·1	Fair observation.
Nov. 5	8 0	115	l + 4 ; m − 3...	13·0 13·0	13·0	Stars low. Obs. difficult.
11	8 23	115	l + 3 ; m − 4...	12·9 12·9	12·9	Obs. a little difficult.
Dec. 17	8 5	115	= 11·5 ...	11·5	11·5	Difficult obs. Haze and bright moonlight.
1892. Jan. 4	8 24	70	= 112 ? ...	11·2	11·2	11¼ est. Obs. difficult and doubtful. Hazy.

Mr. Knott's Diagram, Epoch 1860 ?

S Ursæ Majoris.



[The numbers assigned in the above diagram are ten times the assumed magnitudes of the stars.]

Baxendell's, sen., Letters.	Peek's Mags.	Pogson's Mags.	Baxendell's, jun., Mags.
a	6·1	6·3	6·3
b	6·9	6·9	6·9
c	7·0	7·1	7·1
e	8·1	8·9	8·9
g	9·8	10·7	10·9
k	10·3	11·4	var.

S Ursæ Majoris.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379):—

No. 4557 *S Ursæ Majoris*, R.A. for 1900·0 = $12^h\ 39^m\ 34^s$, Decl. = $+61°\ 38'·4$.

Annual Variation $+2^s·63$ and $-0'·33$.

R.A. for 1855·0 = $12^h\ 37^m\ 35^s$, Decl. = $+61°\ 53'·3$.

Redness = 3·2. Max. mag. 6·7—8·2. Min. 10·2—11·5.

$M - m = 113·0$.

Maximum: 1860 June 24 = $2400586^d·0$ (Julian).

Periodicity represented by $+226^d·1$ E. $+ 43^d$ sin (5°·76 E. + 181°·5), where E. is the number of periods.

(From fifty-nine observations of Max. and thirty-seven of Min., including observations in 1790, 1843–95.)

Discovered by Pogson, 1853.

S Ursæ Majoris.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865. May 25·5	h m	60	8·5 ± ...	...	8·5 ±	
July 19·5		60	= 107; 112 − 5	10·7 10·7	10·7	
28·5		60	107 + 3 + 4; 112 − 1	11·0 11·1 11·1	11·1	
Aug. 9·4		60	112 + 1 + 2; 114 − 1	11·3 11·4 11·3	11·3	
14·4		60	114 + 1 + 2; 116 − 1	11·5 11·6 11·5	11·5	
24·4		60	= 116; 114 + 2	11·6 11·6	11·6	
Sept. 7·4		60	116 + 1 + 2 ...	11·7 11·8	11·75	
18·3		60	= 116; 114 + 2	11·6 11·6	11·6	
Oct. 3·4		70	107 − 2; 112 − 6	10·5 10·6	10·55	
20·3		70	107 − 5; 93 + 9	10·2 10·2	10·2	
Nov. 1·3		60	89 + 0 + 1; 93 − 3	8·9 9·0 9·0	9·0	
3·4		70	= 89 ...	8·9	8·9	
13·3		60	89 − 1 ...	8·8	8·8	
18·3		70	89 − 1 − 2 ...	8·8 8·7	8·75	Decidedly ruddy.
29·3		70	75 + 9; 89 − 5	8·4 8·4	8·4	Fine ruddy.
Dec. 14·3		...	75 + 5; 89 − 6 − 7 ...	8·0 8·3 8·2	8·2	Red decidedly.
30·3		70	69 + 10; 75 + 5; 89 − 10	7·9 8·0 7·9	7·9	
1866. Jan. 6·5		70	75 + 7; 89 − 7?	8·2 8·2	8·2	Observation rather uncertain.
12·3		70	89 − 7; 75 + 7	8·2 8·2	8·2	Ruddy. 8·2 estimated.
16·4		70	89 − 5; 63 + 20; 75 + 8	8·4 8·3 8·3	8·3	
23·4		70	89 − 6; 75 + 8	8·3 8·3	8·3	
Feb. 3·4		70	89 + 3; 93 − 2	9·2 9·1	9·15	
7·5		70	89 + 2; 93 − 2	9·1 9·1	9·1	Clear, but definition very poor.
17·4		70	93 + 2	9·5	9·5	Ruddy.
Mar. 10·3		70	= 107; 112 − 5	10·7 10·7	10·7	
16·4		70	112 + 1; 114 − 1	11·3 11·3	11·3	
Apr. 13·4		70	116 + 4; 125 − 5	12·0 12·0	12·0	
25·3		70	= 116; 114 + 2	11·6 11·6	11·6	
May 16·4		70	= 107 ...	10·7	10·7	Ruddy.
June 7·5		70	89 + 4; = 93; = 93 − 1	9·3 9·3 9·2	9·3	
22·4		70	89 − 2 ...	8·7	8·7	Ruddy.
26·4		70	89 − 3 ...	8·6	8·6	
July 9·4		70	75 + 9; 89 − 5	8·4 8·4	8·4	Ruddy.
14·4		70	75 + 4 ...	7·9	7·9	Decidedly red.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866	h m					
July 20·4		70	75+5 ...	8·0	8·0	Fine red.
Aug. 3·5		70	75+3; 89−11	7·8 7·8	7·8	Ruddy.
16·4		70	63+10; 75−2	7·3 7·3	7·3	Decidedly ruddy.
31·5		70	75+9; 89−4	8·4 8·5	8·45	Ruddy.
Sept. 14·3		60	89+2; 93−2	9·1 9·1	9·1	Pale ruddy orange.
Oct. 8·3		70	107−4; 112−10	10·3 10·2	10·25	
22·3		70	=112	11·2	11·2	Moonlight.
Nov. 13·3		70	=116 ...	11·6	11·6	
27·3		70	116+4 ...	12·0	12·0	
Dec. 7·3		70	107+4; 112−1	11·1 11·1	11·1	
19·3		70	107−2; 93+12	10·5 10·5	10·5	Ruddy?
1867. Jan. 4·3		70	=93... ...	9·3	9·3	Decidedly red.
11	11 +	70	89+4; 93−0−1 ...	9·3 9·3 9·2	9·3	Fine red, rather pale.
Feb. 6	11 25	70	75+11; 89−2	8·6 8·7	8·65	Very decidedly orange ruddy.
14	9 ±	70	75+7; 89−7	8·2 8·2	8·2	Ruddy orange.
Mar. 2	11 ±	70	75+4; 89−10	7·9 7·9	7·9	Pale red.
Apr. 29	11 ±	70	93+4+5; 107−10	9·7 9·8 9·7	9·7	Ruddy orange.
May 21	11 30	70	93+11; 107−3	10·4 10·4	10·4	Dull red?
June 4	11 —	70	=114 ...	11·4	11·4	
26	12 ±	70	116+0+1 ...	11·6 11·7	11·65	So Mrs. Knott.
July 5	11 45±	70	=116 ...	11·6	11·6	
9	11 40	70	=116 ...	11·6	11·6	
16	11 40	89	116+2 ...	11·8	11·8	Clear sky. Moonlight. A stiff breeze from the S.W.
27	10 30±	70	114+1; 116−1	11·5 11·5	11·5	
Aug. 2	11 —	60 70	107+3; 112−2	11·0 11·0	11·0	
9	11 20	70	107−2; 98+7	10·5 10·5	10·5	Decidedly red. 5-inch aperture.
20	9 —	60	93+2+3; 107−11	9·5 9·6 9·6	9·6	Dull red. 5-inch aperture. Bar in e.p.
Sept. 5	9 0	....	89−2 ...	8·7	8·7	Coppery red.
10	11 0	70	75+12; 89−2	8·7 8·7	8·7	Fine clear red.
Oct. 5	8 0	70	75+10; 89−4−5	8·5 8·5 8·4	8·5	Obs. rather doubtful. Hazy.
19	8 45	70	89−3; 75+10	8·6 8·5	8·55	Clear carmine.
Nov. 2	9 —	70	89−6; 75+8+9	8·3 8·3 8·4	8·3	Very decidedly ruddy.
Dec. 7	11 0	70	93+2 ...	9·5	9·5	Clear pale red.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867. Dec. 26	h m 8 0	70	93+10; 107−4	10·3 10·3	10·3	Ruddy. After making this obs. I walked out of the observatory and found the air quite clear and the stars shining brightly. I had hardly returned into the observatory when a *ground mist*, which had been more or less prevalent during the day, came up with a slight S.S.E. breeze and entirely obscured the stars. I cannot now (8^h 10^m) see a *single star*!
1868. Jan. 20	11 40	60	112+2; =114	11·4 11·4	11·4	
Feb. 6	11 10	70	11·8 ± ...	...	11·8 ±	Obs. interrupted by clouds. $S < 116$—*perhaps* 12. Obs. terminated at 11·15 by thick hazy clouds blown up from W.N.W.
11	12 0	70	=125 ...	12·5	12·5	Well seen. Clear.
Apr. 2	9 15	70	89+1; 93−3	9·0 9·0	9·0	Ruddy.
May 14	12 5	70	89−4 ...	8·5	8·5	8½ est. Fine clear orange red.
27	10 50	70	75+4; 89−10	7·9 7·9	7·9	Ruddy decidedly with delicate lilac cast.
June 5	11 25	70	75+2 ...	7·7	7·7	Delicate ruddy with slight purple cast.
15	10 45	70 38	75+4; 89−10	7·9 7·9	7·9	Clear ruddy with lilac cast.
29	11 30	70	... ...	8·0 ±	8·0 ±	Less than 75. Delicate pale red, with slight lilac tinge?
July 20	10 30	70	89+3; 93−1	9·2 9·2	9·2	Ruddy lilac. A delicate colour.
Aug. 3	11 15	70	93+6; 107−8	9·9 9·9	9·9	Ruddy lilac.
Sept. 5	9 10	70	=116 ...	11·6	11·6	Careful observation.
30	7 50	89	=125; 125+?	12·5 ±	12·5 ±	Faint but well seen.
Oct. 7	8 45	70	125 ± ...	12·5 ±	12·5 ±	9^h past meridian.
Nov. 2	11 30	70	107−2 ...	10·5	10 5	
Dec. 19	8 55	70	75+12; 89−2	8·7 8·7	8·7	Clear coppery yellow with a slight lilac tinge.
1869. Jan. 5	9 15	70	75+3; 89−11	7·8 7·8	7·8	Ruddy lilac.
19	12 35	70	... ...	7·8 ± est.	7·8 ± e.	Clear *red* lilac.
Feb. 2	8 50	70	... ...	8·0 est.	8·0 e.	Ruddy with slight lilac cast.
19	7 35	70	89+1; 93−3	9·0 9·0	9·0	Red clear and delicate. I do not notice any tinge of lilac.
27	9 5	70	89+2; 93−2	9·1 9·1	9·1	Ruddy lilac. Brt. moonlight. Clds. came up.
Apr. 1	9 20	70	93+10; 107−4	10·3 10·3	10·3	Fair obs. but sky very hazy. Wind N.E.
June 15	11 55	70	93+7; 107−7	10·0 10·0	10·0	"*Grape red*" ruddy with slight lilac tinge.
July 10	11 35	70	75+2; 89−12	7·7 7·7	7·7	Clear coppery red with slight lilac cast. A delicate tint.
Aug. 6	11 15	70	75+6; 89−8	8·1 8·1	8·1	Ruddy lilac colour.
26	10 37	70	75+8; 89−6	8·3 8·3	8·3	Ruddy with lilac cast. Moonlight.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Sept. 21	h m 8 45	70	89+2; 93−2	9·1 9·1	9·1	Rose colour with lilac tinge.
Oct. 11	8 16	70	93+5; 107−9	9·8 9·8	9·8	Ruddy lilac.
26	7 28	70	93+8; 107−6	10·1 10·1	10·1	Dull orange.
Nov. 30	7 15	70	Not seen ...	Under 11·2	< 11·2	107 and 112 seen. Stars $11\frac{1}{4}^h$ past meridian and among trees. Obs. worth but little.
Dec. 24	7 55	70 89	... ...	...	12 ± est.	Low. $10\frac{1}{2}^h$ fr. meridian.
1870. Apr. 2	8 40	70	75+8; 89−6	8·3 8·3	8·3	A delicate red, with lilac cast.
May 7	11 5	70	=93... ...	9·3	9·3	Clear rose colour.
June 6	11 47	70	107−1−2 ...	10·6 10·5	10·55	*S* lilac tint.
Oct. 26	7 0	70	=89... ...	8·9	8·9	Ruddy with lilac tinge.
1871 Jan. 12	8 35	70	93+5; 107−9	9·8 9·8	9·8	Ruddy lilac tint.
Feb. 8	8 50	70 89	=112 ...	11·2	11·2	Careful comparison.
Mar. 1	9 5	70	$12\frac{1}{4}$ est. ...	12·25	12·25	Careful estimation.
18	9 35	70	13 0 est. ...	13·0	13·0	Well seen.
May 17	11 35	70	107−12; 93+12	9·5 9·5	9·5	Ruddy lilac. A delicate tint.
June 5	11 40	70	89−3 ...	8·6	8·6	Red lilac.
28	11 25	70	75+3 ...	7·8	7·8	Delicate lilac tint. Bright 8th mag.
July 22	11 50	70	75+7; 89−7	8 2 8·2	8·2	8 $8\frac{1}{4}$ est. Clear red with slight purple cast.
Aug. 15	11 35	70	8·6 est. ...	8·6	8·6	> 89. Rose red.
Sept. 11	8 40	70	93+11; 107−3	10·4 10·4	10·4	Obsd. among clouds.
Oct. 14	7 10?	70	114+6; 125−5	12·0 12·0	12·0	Clear. Well seen.
Dec. 20	12 5	70	89−2−3 ...	8·7 8·6	8·65	Ruddy with slight lilac tinge.
1872. Mar. 5	11 5	70	75+5 ...	8·0	8·0	8 ± est. Ruddy lilac tint.
Apr. 13	11 35	70	=93... ...	9·3	9·3	Ruddy lilac. A delicate tint.
June 13	11 10	70	116+10; 125+1	12·6 12·6	12 6	
Aug. 31	9 35	70	75+6; 89−8	8·1 8 1	8·1	8 or $8\frac{1}{2}$ est. Ruddy lilac.
Dec. 7	11 30	70	93+7; 107−7	10·0 10·0	10·0	Ruddy lilac. 10 mag. est.
1877. Jan. 25	12 0	70	89−3 ...	8·6	8 6	Ruddy lilac.
Feb. 16	7 50	70	75+7; 89−7	8·2 8·2	8 2	Ruddy lilac.
Mar. 21	9 10	70	75+7; 89−7	8·2 8·2	8·2	Lilac with red shade. A delicate tint. About $8\frac{1}{4}$ est.
Apr. 10	9 0	90	=89; 89−1; 93−4	8·9 8·8 8·9	8·9	Fine ruddy, decidedly, with slight lilac tinge.
25	11 40	70	93+4+3; 107−11−10	9·7 9·6 9·6 9·7	9·65	A delicate lilac tint.
May 2	10 45	70	93+8; 107−6	10·1 10·1	10·1	Ruddy lilac.
7	10 45	70	93+14; =107	10·7 10·7	10·7	Ruddy with lilac tinge.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877. May 15	h m 10 40	70	107+2; 112−3	10·9 10·9	10·9	Ruddy lilac; decided tint.
June 9	11 5	70	114+6; 125−5	12·0 12·0	12·0	Clear and still.
23	10 55	115	116+6; 125−3	12·2 12·2	12·2	$12\frac{1}{4}$ est.
July 7	12 30	70	=114 ...	11 4	11·4	Clear sky.
26	10 55	70	107+1; 112−4	10·8 10·8	10·8	Ruddy lilac. A decided tint.
Aug. 14	10 35	70	93+4; 107−10	9·7 9·7	9·7	Ruddy lilac.
Sept. 27	12 30	70	71+3; 75−1	7·4 7·4	7·4	Ruddy lilac.
Oct. 5	11 43	70	75+3 ...	7·8	7·8	Red lilac. Abt. $7\frac{3}{4}$ est.
27	11 20	70	75+8; 89−6	8·3 8·3	8·3	Abt. 8 3 est. Ruddy lilac.
Dec. 10	7 20	70	93+9; 107−5	10·2 10·2	10·2	12h from meridian. Lilac tint.
27	7 55	70	107+5; =112	11·2 11·2	11·2	A fair observation.
1878. Jan. 28	11 15	70	=112 ...	11·2	11 2	
Feb. 14	9 5	70	125+5 ...	13·0	13·0	Glimpsed. 13 mag.
Mar. 12	11 40	70	=112 ...	11·2	11·2	A fair obs.
16	10 18	70	107−3 ...	10·4	10·4	Ruddy.
Apr. 3	9 15	70	=89... ...	8·9	8·9	Ruddy lilac. Obs. a little doubtful. 9 mag. est.
May 11	10 53	70	71+5; 75+1; 89−13	7·6 7·6 7·6	7·6	Ruddy with lilac cast.
June 6	13 0	70	75+7; 89−7	8·2 8·2	8·2	Ruddy lilac.
July 3	12 0	70	93+2; 107−12	9·5 9·5	9·5	Pale lilac tint?
Aug. 1	12 55	70	93+12; 107−2	10·5 10·5	10·5	Slightly lilac tint?
Oct. 12	10 55	115	116+4; 125−5?	12·0 12·0	12·0	12h from meridian. Fairly clear. Abt. 12 mag.
1881. Mar. 22	10 12	70	126+4 ...	13·0	13·0	13 est.
1882. Jan. 24	10 15	70	=89... ...	8·9	8·9	Ruddy lilac tint.
Feb. 15	10 20	70	75+2 ...	7·7	7·7	$7\frac{3}{4}$ or a bright 8 mag. est.
Mar. 3	8 59	70	=75... ...	7·5	7·5	7·5 gauged. Ruddy lilac.
16	10 28	70	75+2 ...	7·7	7·7	Barely equal 75. Ruddy lilac.
22	8 38	70	75+3 ...	7·8	7·8	Ruddy with lilac tinge.
31	9 5	70	8·1 gauged ...	...	8·1	8·1 gauged. Lilac ruddy.
Apr. 20	10 30	70	75+12; 89−2	8·7 8·7	8·7	Ruddy lilac. $8\frac{3}{4}$ est.
May 20	10 15	70	107−0−1 ...	10·7 10·6	10·65	
1883. Feb. 6	8 50	70	=112 ..	11·2	11·2	Qu. 114 rated rather too low?
24	9 0	70	... ..	12·25	12·25	12. $12\frac{1}{2}$ est.
June 1	10 30	70	75+4 ...	7·9	7·9	Ruddy lilac. About 8 mag.
1884. Nov. 15	9 20	70	107−3; 93+11	10·4 10·4	10·4	Nearly 12h from meridian.
22	8 55	70	=107−1−2	10·6 10·5	10·55	63 hidden by bar.
28	8 55	70	=107 ...	10·7	10·7	Haze and moonlight.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884.	h m					
Dec. 4	9 5	115	= 107 ...	10·7	10·7	Not less than this star, I think.
15	9 5	70	107 + 2 ...	10·9	10·9	Qu. 114 more like 110?
1885.						
Jan. 7	9 15	70	112 + 2 ; 116 − 2	11·4 11·4	11·4	
Feb. 5	7 45	70	= 114 ; 116 − 2 ; 107 +	11·4 11·4	11·4	112 more like 115. Qu. 107 too highly rated?
18	10 55	70	93 + 6 ...	9·9	9·9	9·8 9·9 gauged.
Mar. 7	8 40	70	89 + 1 ; 93 − 3	9·0 9·0	9·0	Delicate orange ruddy. 9·0 gauged.
14	9 50	70	8·9 gauged ...	...	8·9	Ruddy orange.
20	9 5	70	89 − 1 ...	8·8	8·8	8·8 gauged. Ruddy orange.
30	10 10	70	89 − 5 ; 75 + 9	8·4 8·4	8·4	Ruddy.
Apr. 18	10 50	70	About = 75 ...	7·5	7·5	Ruddy orange.
May 11	10 45	70	71 + 2 ; 75 − 2	7·3 7·3	7·3	Orange tint.
29	10 25	70	75 + 3 ; 89 − 11	7·8 7·8	7·8	Ruddy lilac.
June 17	11 15	70	89 + 3 + 4 ; = 93	9·2 9·3 9·3	9·3	Slight ruddy tint.
July 10	12 5	70	107 + 3 ; 112 − 2	11·0 11·0	11·0	
20	10 30	115	107 + 5 ; = 112 ; 114 − 2	11·2 11·2 11·2	11·2	
Aug. 10	11 36	70	116 + 4 ; 125 − 5	12·0 12·0	12·0	12·0 ± est.
29	8 45	115	= 125 ...	12·5	12·5	About $12\frac{1}{2}$ est.
Oct. 27	7 20	70	93 + 10 ; 107 − 4	10·3 10·3	10·3	10·3 gauged. Lilac tint. A delicate colour.
Dec. 15	10 45	70	75 + 9 ; 89 − 5	8·4 8·4	8·4	8·4 gauged. Orange red.
1886.						
May 15	8 55	70	107 + 2 ; 114 − 5	10·9 10·9	10·9	Rather doubtful.
June 1	10 45	70	93 + 0 + 1 ...	9·3 9·4	9·35	Ruddy.
23	11 53	70	89 − 1 ; 93 − 5	8·8 8·8	8·8	Orange tint.
30	11 34	70	75 + 7 ; 89 − 7	8·2 8·2	8·2	Clear ruddy orange.
July 5	11 45	70	89 − 3 ; 75 + 11	8·6 8·6	8·6	8·6 gauged. Ruddy. Is *S less* than when last seen?
15	10 55	70	89 − 6 ; 75 + 8	8·3 8·3	8·3	Ruddy with lilac tinge.
24	11 5	70	75 + 5 ; 89 − 9	8·0 8·0	8·0	Ruddy lilac.
Aug. 10	10 57	70	75 + 2 ...	7·7	7·7	Rose tint.
Sept. 30	7 25	70 115	93 + 7 ; 107 − 7	10·0 10·0	10·0	About 10 mag. est. Ruddy lilac.
Nov. 16	7 52	115	114 + 9 ; 125 − 2	12·3 12·3	12·3	Clear. Well seen.
29	7 30	70	125 + 5 ...	13·0	13·0	About 13 mag. est.
Dec. 16	7 10	115	116 + 10 ...	12·6	12·6	$12\frac{1}{2}$ est. 12^h from meridian. Fair obs.
1887.						
Jan. 12	10 0	115	93 + 11 ; 107 − 3	10·4 10·4	10·4	Rather hazy sky.
20	8 0	70	93 + 10 ; 107 − 4	10·3 10·3	10·3	Rather hazy.
25	7 25	70	93 + 2 ; 107 − 12	9·5 9·5	9·5	Ruddy, with lilac tinge?
Feb. 1	10 0	70	89 + 0 + 1 ; 93 − 4 · 3 ...	8·9 9·0 8·9 9·0	8·95	9·0 gauged. Ruddy with lilac tinge.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887. Feb. 7	h m 10 0	70	89−1 ...	8·8	8·8	Ruddy lilac.
12	8 25	70	89+1 ...	9·0	9·0	9·0 gauged. Delicate orange ruddy.
14	7 50	70	89+0+1 ...	8·95	8·95	Perhaps *barely* = 89. Orange ruddy. Gauged 8·9 9·0. 89 gauged 8·9.
16	10 17	70	89−1−2 ...	8·8 8·7	8·75	8·7 gauged. Orange tint.
21	10 20	70	75+10; 89−4	8·5 8·5	8·5	Orange tint?
26	9 0	70	89−5; 75+9	8·4 8·4	8·4	8·4 gauged. Ruddy lilac?
Mar. 1	10 5	70	75+6; 89−8	8·1 8·1	8·1	8·1 gauged. Ruddy.
12	9 0	70	75+5 ...	8·0	8·0	8·0 gauged. Slightly ruddy.
16	9 5	70	75+4 ...	7·9	7·9	7·9 gauged. Orange ruddy.
26	8 50	70	75+7; 89−7	8·2 8·2	8·2	Rather doubtful observation. Sky not clear. *S* orange tint.
Apr. 8	9 15	70	75+9; 89−5	8·4 8·4	8·4	8·4 gauged orange tint.
16	10 10	70	89−3 ...	8·6	8·6	Red orange. 8·6 gauged.
30	10 17	70	89+2; 93−2	9·1 9·1	9·1	Ruddy orange tint.
May 10	11 5	70	=93... ...	9·3	9·3	Ruddy.
June 13	10 40	70 115	107+3; 114−4	11·0 11·0	11·0	11 est. ruddy.
18	11 5	115	107+3; 112−2	11·0 11·0	11·0	
30	11 40	70	112+2; =114	11·4 11·4	11·4	Clear sky.
July 18	11 12	115	112+2; 116−2	11·4 11·4	11·4	
21	11 18	70	114+1; 116−1	11·5 11·5	11·5	About 11·5 est.
Aug. 12	10 55	70	107+3; 112−2	11·0 11·0	11·0	About 11 est.
22	10 40	70	93+12; 107−2	10·5 10·5	10·5	Ruddy.
Oct. 1	8 25	70	75+5; 89−7	8 0 8·2	8·1	About 8 mag. Orange with ruddy tinge.
11	8 15	70	75+10; 89−4	8·5 8·5	8·5	Ruddy. 8·5 gauged.
19	8 30	70	89−7; 75+7	8 2 8·2	8·2	Ruddy.
31	8 0	70	75+3 ...	7·8	7·8	7·9 gauged. Ruddy.
Nov. 14	8 50	70	89+1·5; 93−1·5	9·05 9·05	9·05	Orange red.
30	8 0	70	89+1; 93−2	9·0 9·0	9·0	Orange tint. 12^{h} from meridian.
Dec. 15	8 0	70	93+7; 107−7	10·0 10·0	10·0	
1888. Jan. 9	8 0	70	107−2? ...	10·5?	10·5±	About 10·5? Rather brighter than 107? A heavy ground mist. Obs. very difficult.
10	7 20	70	=107; 112−5	10·7 10·7	10·7	Clear. 10^{h} from meridian.
18	7 25	70	107+2; 112−3	10·9 10·9	10·9	114 = 11·0 mag.?
23	8 0	70	=112 ...	11·2	11·2	
Mar. 1	7 30	115	125+5 ...	13·0	13·0	13·0 est.
21	8 45	70	107−1 ...	10·6	10·6	
May 1	8 40	70	75+10; 89−4	8·5 8·5	8·5	8·5 gauged. Ruddy orange.
10	10 0	70	75+10; 89−4	8·5 8·5	8·5	Orange ruddy.

S Ursæ Majoris—continued.

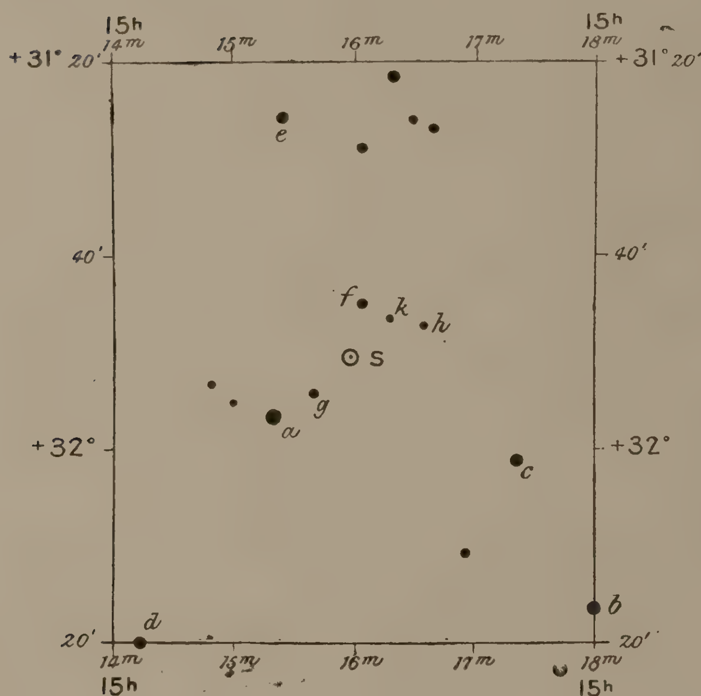
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1888.	h m					
May 23	10 5	70	75+7; 89−7	8·2 8·2	8·2	Orange red.
Aug. 8	11 5	70	98+9; =107	10·7 10·7	10·7	Ruddy.
Oct. 5	7 20	70 115	125+3 ...	12·8	12·8	About 13 mag.
11	8 37	70	125−1 ...	12·4	12·4	About 12½ est. Not less than 125.
18	7 15	115	=125 ...	12·5	12·5	
23	7 15	115	116+2; 125−7	11·8 11·8	11·8	Clear sky.
27	7 0	70	116+3; 125−6	11·9 11·9	11·9	Not very clear.
Nov. 6	7 0	70	107+2; 112−3	10·9 10·9	10·9	
13	7 53	70	107−2; 93+12	10·5 10·5	10·5	Ruddy.
20	8 5	70	93+10; 107−4	10·3 10·3	10·3	Slightly ruddy.
Dec. 6	7 20	70	93+8; 107−6	10·1 10·1	10·1	Rather hazy.
12	7 10	70	=93; 89+4	9·3 9·3	9·3	
26	8 10	70	89+4; =93	9·3 9·3	9·3	Orange red.
1889.						
Jan. 27	8 53	70	89−3 ...	8·6	8·6	8·6 gauged. Ruddy orange.
Feb. 2	8 30	70	89−4 ...	8·5	8·5	Ruddy orange; gauged 8·6±.
21	8 45	70	75+10; 89−4	8·5 8·5	8·5	Full orange red.
Mar. 6	9 0	70	89−3; [75+11]	8·6 [8·6]	8·6	Orange ruddy.
June 3	10 18	70	125−2; 116+7	12·3 12·3	12·3	
Sept. 6	9 58	70	75+5; 89−9	8·0 8·0	8·0	Ruddy.
10	8 16	70	75+5; 89−9	8·0 8·0	8·0	8·0 8·1 gauged. Ruddy orange.
Oct. 23	7 45	70	93+4; 104−7	9·7 9·7	9·7	Ruddy? Doubtful observation. Hazy.
25	7 7	70	=93... ...	9·3	9·3	Orange ruddy.
31	7 8	70	93+3 ...	9·6	9·6	Pale ruddy.
Nov. 12	8 45	70	=107 ...	10·7	10·7	Slightly ruddy?
25	8 32	70	114−1 ...	11·3	11·3	About 11¼ est.
30	8 42	70	112+2; =114	11·4 11·4	11·4	
Dec. 4	8 38	70	112+2; =114	11·4 11·4	11·4	
24	8 30	70	116+6; 125−3	12·2 12·2	12·2	
1890.						
Apr. 1	9 50	70	75+7; 89−7	8·2 8·2	8·2	Ruddy orange tint. Abt. 8¼ est.
22	10 20	70	75+2 ...	7·7	7·7	Orange ruddy. Observation rather doubtful.
Aug. 4	10 30	115	116+4; 125−5	12·0 12·0	12·0	Abt. 12 mag. est.
8	10 17	115	116+7; 125−2	12·3 12·3	12·3	A faint 12 mag. est.
18	9 40	115	Not seen ...	...	...	Not seen, nor any of the faint stars near 63. Hazy sky.
23	9 53	115	116+6; 125−3	12·2 12·2	12·2	Clear sky.
30	8 47	115	116+6; 125−2	12·2 12·3	12·25	Obsd. with difficulty. Hazy sky.
Sept. 4	9 42	115	112+4; 114+2; =116	11·6 11·6 11·6	11·6	Well seen. Brightening up.
8	9 45	70	112+2; =114	11·4 11·4	11·4	Brightening up decidedly.

S Ursæ Majoris—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1890. Sept. 13	h m 8 3	70	107 + 3; 112 − 2	11·0 11·0	11·0	Ruddy?
15	8 51	70	= 107 ...	10·7	10·7	Ruddy.
Oct. 25	7 53	70	89 − 2 ...	8·7	8·7	Pale orange ruddy.
Nov. 4	7 15	70	75 + 10; 89 − 4	8·5 8·5	8·5	Ruddy orange tint.
Dec. 9	8 30	70	89 − 5; 75 + 9	8·4 8·4	8·4	Orange red.
13	7 50	70	89 − 2; 75 + 12	8·7 8·7	8·7	Orange red, full coloured.
1891. Jan. 1	7 50	70	= 93... ...	9·3	9·3	Orange ruddy.
Feb. 4	10 55	70	93 + 10; 107 − 4	10·3 10·3	10·3	
20	8 25	70 115	107 + 3 ...	11·0	11·0	Moonlight and hazy sky. Very bad for observation. Failed to see *R Ursæ Maj*. White filmy haze all over sky.
26	8 10	70	107 + 3; 112 − 2	11·0 11·0	11·0	114 more like 10·9?
Mar. 3	8 3	70	107 + 3 + 5; 112 − 2 − 0	11·0 11·2 11·0 11·2	11·1	Bad definition. 114 = 107 − 2? ∴ 10·5? ½ mag. or more brighter than *S*. High wind. Very bad definition but sky clear.
27	8 53	70 115	12·4 12·5 gauged	12·4 12·5	12·45	Pogson's 12·5 gauged 12·2 12·3.
May 7	10 22	70	107 − 2 ...	10·5	10·5	Ruddy.
June 5	11 0	70	= 89... ...	8·9	8·9	Orange ruddy.
July 28	11 5	70	75 + 2 ...	7·7	7·7	Orange red.
Aug. 10	10 50	70	= 89... ...	8·9	8·9	Ruddy decidedly.
Oct. 12	9 55	115	107 + 5; = 112	11·2 11·2	11·2	
23	8 19	115	114 + 2; = 116	11·6 11·6	11·6	Obs. a little doubtful.
28	7 46	70	116 + 4; 114 + 6	12·0 12·0	12·0	Abt. 12 mag. est.
Nov. 5	8 8	115	116 + 1 ...	11·7	11·7	Doubtful observation.
11	8 30	115	116 + 4; 125 − 5	12·0 12·0	12·0	Fair observation.
Dec. 17	8 11	70	93 + 7; 107 − 7	10·0 10·0	10·0	Ruddy.
1892. Jan. 4	8 31	70	93 + 3 ...	9·6	9·6	Ruddy. Obs. a little difficult and doubtful. Hazy sky.

Mr. Knott's Diagram, Epoch 1865·0.

S Coronæ Borealis.



Magnitudes of Comparison Stars :

$a = 6{\cdot}8$	$d = 8{\cdot}6$	$g = 11{\cdot}3$
$b = 7{\cdot}9$	$e = 8{\cdot}8$	$h = 11{\cdot}9$
$c = 8{\cdot}2$	$f = 10{\cdot}2$	$k = 12{\cdot}6$

Chart and mags. by J. Baxendell, Esq.

S Coronæ Borealis.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 5504 *S Coronæ*, R.A. for 1900·0 = $15^h\ 17^m\ 19^s$, Decl. = $+31°\ 43'·6$.

Annual Variation = $+2^s·45$ and $-0'·22$.

R.A. for 1855·0 = $15^h\ 15^m\ 29^s$, Decl. = $+31°\ 53'·5$.

Redness = 4·9. Max. mag. = 6·1 – 7·8. Min. = 11·9 – 12·5.

M – m = 116^d.

Max. : 1860 Aug. 24 = 2400647^d (Julian).

Period = $360^d·8$.

(From twenty-nine observations of Max. and ten of Min., including observations in 1860–93.)

Discovered by HENCKE, 1860.

S Coronæ Borealis.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866.	h m					
Feb. 19·5		70	$k+3+4$ ...	12·9 13·0	12·95	Photometric determination of mags. of Mr. Baxendell's Comp. Stars. $a=6·8$; $c=8·2$; $f=10·3$; $g=11·5$; $h=12·0$; $k=12·5$. The last three estimated.
21·4		70	$k+2$... ...	12·8	12·8	Gauged the mags. of Mr. Baxendell's Comp. Stars as follows: $a=6·8$; $b=7·8$; c 8·1; d 8·6; e 8·8; $f=10·3$ 10·2; g 11·4; h 11·9; k 12·5.
Mar. 16·4		70	$k+5+6$ ...	13·1 13·2	13·15	
Apr. 4·3		70	... ...	13·3 est.	13·3 est.	Considerably $< k$.
13·5		70	... ...	13·3 est.	13·3 est.	
May 4·3		70	... ...	12·8 ±	12·8 ±	
16·4		70	$=h$; $g+6+7$	11·9 11·9 12·0	11·9	
June 7·5		89	$g+3+4$ ...	11·6 11·7	11·65	
22·4		70	$=f$	10·2	10·2	Decidedly ruddy.
26·4		70	$f-3$	9·9	9·9	Decidedly pale red.
July 9·4		70	$b+3$; $=c$; $d-4$	8·2 8·2 8·2	8·2	Decidedly red.
10·5		70	$=c$; $d-4$ ...	8·2 8·2	8·2	Fine ruddy colour.
14·4		70	$=c$	8·2	8·2	After careful comparison. Ruddy, not deep.
19·4		70	$b+1$; $c-2$ ...	8·0 8·0	8·0	Fine orange red.
Aug. 3·4		70	$=b$? considerably $< a$ ...	7·9	7·9	Decidedly red. Among clouds.
9·4		70	$b+2$; $c-1$ ...	8·1 8·1	8·1	Fine red orange.
16·4		70	$b+2$; $c-1$ ...	8·1 8·1	8·1	Fine red. Most certainly to my eye less than b. Qu. b more than $3 > c$?
31·5		70	$=c$; $d-4$ ...	8·2 8·2	8·2	$7\frac{1}{2}^h$ past meridian. Moon rising.
Sept. 14·3		60	$c+1$; $d-4$...	8·3 8·2	8·25	Fine ruddy.
Oct. 8·3		70	$c+4$; $=d$; $e-2$	8·6 8·6 8·6	8·6	Fine ruddy.
Nov. 3·3		70	$e+4$; $f-10$	9·2 9·2	9·2	
6·3		70	$e+3+4$; $f-9-10$	9·1 9·2 9·3 9·2	9·2	Fine red. A hazy look about the star.
19·3		70	$e+6$; $f-8$ ...	9·4 9·4	9·4	Far from meridian and obs. very doubtful. Star decidedly red.
1867.						
Mar. 2	12 30	70	$k+2+3$ ...	12·8 12·9	12·85	$12\frac{3}{4}$ ± est.
Apr. 29	11 0 ±	70	$g+0+1$ ...	11·3 11·4	11·35	
May 3	12 15 ±	70	$g+3$... ...	11·6	11·6	
21	10 40	70	$f+9$; $g-2$...	11·1 11·1	11·1	
24	12 45 ±	70	$f+8$; $g-3$...	11·0 11·0	11·0	
30	11 30	70	$f+7$; $g-4-5$	10·9 10·9 10·8	10·9	Decidedly red, fine colour.
June 1	13 40	70	$f+4$; $g-7$ ...	10·6 10·6	10·6	Red.
4	11 0	70	$f-2$	10·0	10·0	Clear red.
7	10 10 ±	70	$f-2-3$ ...	10·0 9·9	9·95	Decidedly red. Cloudy.

S Coronæ Borealis—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
June 10	12 0±	70	$e+7$; $f-7$ ...	9·5 9·5	9·5	Decidedly red.
26	11 +	70	$=c$	8·2	8·2	Fine orange red. b more than $3>c$?
28	11 ±	70	$b+1$; $c-2$ ...	8·0 8·0	8·0	Fine golden with ruddy cast. b more than $3>c$?
July 5	11 10±	70	$a+10$; $b-1$	7·8 7·8	7·8	Fine orange red. $4\frac{1}{2}$-inch aperture.
9	11 20±	70	$a+7$; $b-4$ ...	7·5 7·5	7·5	Decidedly red. 5-inch aperture.
16	10 50	70	$a+4+5$; $b-6-7$	7·2 7·3 7·3 7·2	7·25	Moonlight. *S* coppery red. Full aperture and also aperture of 2·7 inches.
27	10 ±	70	$a+5$; $b-6$ ...	7·3 7·3	7·3	Fine red orange.
31	11 0	70	$a+2$; $b-9$ ...	7·0 7·0	7·0	Fine coppery red. 5-inch aperture. Wind easterly. Still. Definition not very good.
Aug. 2	10 35	70	$=a$; $a+1$? ...	6·8 6·9	6·85	In *finder* barely $=a$. Fine orange red contrasting in colour with that of *a*, which is white or pale yellow. Obs. with full aperture and with one of 4 inches.
9	10 50	70	$a-2$ ...	6·6	6·6	Certainly *not less* than *a*. *S* coppery red. *a* white or v.p. yellow. 5-inch aperture.
12	11 0±	70	$a-2-3$ ...	6·6 6·5	6·55	Orange red. Certainly not less than *a*, and to my eye decidedly brighter.
20	8 30	70	$a-2$ ...	6·6	6·6	In *finder* about equal to *a*. *S* fine orange, *a* white, or v.p. yellow. The colours so different that it is not easy to compare them in magnitude. To my eye *S* is certainly *not less than a*.
23	8 50	70	$=a$	6·8	6·8	Fine orange red. $2\frac{1}{2}$ and 5 inches aperture.
Sept. 3	10 45	70	$a+5$? ...	7·3	7·3	Orange red. 6ʰ past meridian and among clouds. Obs. rather doubtful. Air close. Lightning flashes.
5	8 30	70	$a+3$; $b-8$ ...	7·1 7·1	7·1	5-inch aperture. *S* fine orange red.
10	10 30±	70	$a+3$? ...	7·1	7·1	Fine coppery red, contrasting finely with the white colour of *a*. Surely *b* must be more than 1·1 mag. $<a$. 5-inch aperture.
Oct. 5	6 50±	70	$a+10$; $c-4$	7·8 7·8	7·8	Among clouds. Dull red. Obs. very doubtful.
19	7 40	70	$c+2+3$; $d-1-2$	8·4 8·5 8·5 8·4	8·45	Decidedly ruddy.
Nov. 13	6 10	70	$e+4$; $f-10$	9·2 9·2	9·2	$6\frac{1}{2}^h$ past meridian. Obs. rather uncertain. *S* dull red, not sharply defined. 5-inch aperture.
1868. Feb. 11	12 35±	89	$g-1$	11·2	11·2	
Apr. 2	9 25	70 191	... ...	11·8	11·8	Carefully compared with *g*.
May 14	11 0	70	$f+8$; $g-3$ ...	11·0 11·0	11·0	Decidedly ruddy.

S Coronæ Borealis—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1868.	h m					
May 18	10 30	89	$f+8$; $g-3$...	11·0 11·0	11·0	*S* ruddy? Not good definition.
23	10 45	70	$f+7$; $g-4$...	10·9 10·9	10·9	*S* of a ruddy hue. Qu. *f* rather brighter than 10·2??
26	10 50	70	$f+3$; $g-8$...	10·5 10·5	10·5	Ruddy.
June 5	10 15	70	$e+11$; $f-3$	9·9 9·9	9·9	Clear carmine. Bright moonlight.
13	10 30	70	$e+7$; $f-7$...	9·5 9·5	9·5	Rather doubtful. Hazy. *S* coppery red.
17	11 0±	70	$c+5$; $e-1$...	8·7 8·7	8·7	Pale ruddy.
23	11 20	70	$b+3$; $=c$; $e-6$	8·2 8·2 8·2	8·2	Pale red.
29	10 50±	70	$a+8$; $b-3$...	7·6 7·6	7·6	Orange with ruddy cast.
July 13	10 5	70	$a+2$; $b-9$	7·0 7·0	7·0	*S* coppery red. It is not easy to estimate the diff. of mag. between *S* and *a*. Sky clear, but defn. bad.
20	10 ±	70	$a+0+2$ ...	6·8 7·0	6·9	*a* v. pale yellow. *S* orange yellow.
25	10 40	70	$a+2$? ...	7·0?	7·0?	Defn. very bad. I should est. *S* abt. 7 mag. Fine ruddy orange.
Aug. 3	10 40	70	$a+2$ ...	7·0	7·0	Orange yellow. *a* pale yellow.
8	10 40	70	$a+3$ ...	7·1	7·1	Ruddy orange. Less than *a* certainly.
21	10 12	70	$a+7$? ...	7·5?	7·5?	Cloud and haze coming up and obs. very doubtful. 5ʰ past meridian.
Sept. 5	8 40±	70	$a+5$; $b-6$...	7·3 7·3	7·3	Fine coppery red. Obs. rather doubtful. 4½-inch aperture.
30	7 0±	70	$b+2+3$; $c-0-1$	8·1 8·2 8·2 8·1	8·15	Fine clear red.
Oct. 7	7 50	70	$b+3$; $=c$ ...	8·2 8·2	8·2	Obs. a little uncertain. Defn. unsteady. *S* fine clear coppery red.
23	7 40	70	$c+2$? ...	8·4?	8·4?	Clear red. 6½ʰ past meridian. Obs. rather doubtful.
Nov. 2	8 15	70	$c+12$; $f-8$	9·4 9·4	9·4	Coppery red. Nearly 8ʰ past meridian.
5	7 0	70	$c+12$; $e+6$; $f-8$	9·4 9·4 9·4	9·4	6ʰ past meridian. Well seen.
1869. Apr. 8	9 15	70	$g+5$; $h-1$...	11·8 11·8	11·8	5ʰ from meridian.
30	10 25	70	$f+10$; $g-1$	11·2 11·2	11·2	Clear. Wind N.E. Defn. poor.
June 15	11 30	70	$c+3$; $d-1$...	8·5 8·5	8·5	Clear pale red. Surely *b* is more than $3>c$.
29	12 35	70	$a+6$; $b-5$...	7·4 7·4	7·4	Full coppery red. In finder, 2-inch aperture, *S* nearer to *b*, rather. Wind N.E. Moon rising. Brilliant but confused.
July 3	10 20	70	$a+6$; $b-5$...	7·4 7·4	7·4	Clear red. Crimson flashes.
10	10 40	70 35	$a+5$; $b-6$; $a+4$	7·3 7·3 7·2	7·3	Clear coppery red. Hazy.
23	11 35	70	$a+4+5$; $b-6-7$	7·2 7·3 7·3 7·2	7·25	Decided orange red.
Aug. 6	9 0	70	$a+6$; $b-5$...	7·4 7·4	7·4	*S* coppery red.
12	10 10	70	$a+8$; $c-6$...	7·6 7·6	7·6	Orange red. 4½-inch aperture.

S Coronæ Borealis—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869	h m					
Aug. 17	9 55	70	$a+12$; $b+1$; $c-2$	8·0 8·0 8·0	8·0	Clear orange red. Full aperture.
24	8 20	70	$b+3$; $=c$ ...	8·2 8·2	8·2	Orange red. Twilight.
Sept. 20	10 35	70 89	$c+2$; $c+3$?	8·4 8·5	8·45	Red. Obs. uncertain, rather, on acct. of moonlight and star being $7\frac{1}{4}^h$ past meridian.
Oct. 9	6 55	70	$c+13$; $f-7$	9·5 9·5	9·5	Coppery red.
26	6 26	70	$c+15$; $f-5$	9·7 9·7	9·7	Coppery tinge.
Nov. 6	7 20	70	9·5 est. ...	9·5 est.	9·5 ±	Ruddy. 7^h past meridian. Careful estimation. f and g in view.
11	6 35	70 89	9·8 est. ...	9·8 est.	9·8 ±	Ruddy decidedly.
20	6 15	89	$f-2$ ...	10·0	10·0	Obs. rather doubtful. Star 7^h past meridian. Sky rather hazy and Moon rising.
1870.						
Apr. 2	9 5	89	$g+3$; $h-3$...	11·6 11·6	11·6	5^h from meridian, but well seen.
25	12 0	60 89	$f+7$; $g-4$...	10·9 10·9	10·9	Decidedly ruddy.
May 2	11 40	89	$f+7$; $g-4$...	10·9 10·9	10·9	Decidedly red.
7	10 20	70	$f+5$; $g-6$...	10·7 10·7	10·7	Ruddy. Clear.
16	10 13	70	$f+2$; $g-9$...	10·4 10·4	10·4	Decided clear red.
June 6	10 45	70	$a+7$; $c-7$...	7·5 7·5	7·5	Golden, with rosy cast.
20	11 55	70	$a-2$ ...	6·6	6·6	Golden with orange cast. In *finder*, 2-in. $=a$.
Oct. 15	8 0	70	$c+3$; $e-3$...	8·5 8·5	8·5	Clear red. $8\frac{1}{2}$ mag. estimated.
26	6 40	70	$c+10$; $e+4$; $f-10$	9·2 9·2 9·2	9·2	Red. Clear sky, but poor definition. Sheet lightning from clouds along S. and W. horizon at intervals.
1871.						
Mar. 13	10 55	70	$k+6$? ...	13·2 est.	13·2	5^h from meridian, but clear, and stars well seen.
18	9 20	102	... ...	$13\frac{1}{4}$ est.	13·25	6^h from meridian. h and k seen.
22	9 30	102	... ...	$13\frac{1}{4}$ $13\frac{1}{2}$ est.	13·4	Not well seen. 6^h from meridian.
24	9 5	156	... ...	13·3 est.	13·3	6^h from meridian. h and k well in view.
Apr. 4	11 5	156	$k+6$? ...	13·2	13·2	Not well seen in bright moonlight. 13·14 est.
May 17	11 25	70	$g+4$; $h-2$...	11·7 11·7	11·7	Clear.
22	11 30	89	$g+0+1$; $h-5$	11·3 11·4 11·4	11·4	Sharply defined. Ruddy?
23	11 40	70	$=g$ ...	11·3	11·3	Slightly ruddy?
June 5	10 25	70	$e+10$; $f-4$	9·8 9·8	9·8	Red decidedly.
26	10 25	70	$a+1+2$; $b-9-10$	6·9 7·0 7·0 6·9	6·95	Orange yellow with ruddy cast. Moonlight.
28	11 35	70	$a+2$ ...	7·0	7·0	Orange red. Moonlight. In finder a greater difference than 0·2.
July 22	10 40	70	$a+3$; $c-11$	7·1 7·1	7·1	Orange red.
29	10 0	70	$a+3+4$ ...	7·1 7·2	7·15	Fine orange red. Moonlight.

S Coronæ Borealis—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871.	h m					
Aug. 15	11 5	70	$=b$ ...	7·9	7·9	Red.
31	10 50	70	$b+3$; $=c$ ...	8·2 8·2	8·2	Fine red.
Sept. 11	8 20	70	$=c$ ...	8·2	8·2	Ruddy. Clouds troublesome.
1872. Feb. 20	12 40	115	Not seen ...	Under $12\frac{1}{2}$	$<12·5$	Less than either h or k certainly.
Mar. 5	10 50	89	$k+6$ ...	13·2	13·2	$13\frac{1}{4}$ est.
9	11 10	89 191	Feebly glimpsed	$13\frac{1}{4}$ est.	13·25 est.	5^h from meridian.
Apr. 13	10 45	156	... ...	13·3 est.	13·3	At least $\frac{1}{2}$ mag. less than k.
May 15	10 50	115	$g+2$; $h-4$...	11·5 11·5	11·5	S slightly ruddy.
21	10 47	115	$f+7$; $g-4$ ..	10·9 10·9	10·9	Slightly red.
27	12 15	70	$f+1$ ...	10·3	10·3	Ruddy decidedly.
June 13	10 30	70	$b+1$; $c-2$...	8·0 8·0	8·0	Orange red.
29	10 56	70	$a+11$; $=b$...	7·9 7·9	7·9	Ruddy orange.
July 9	10 15	70	$a+10$; $b-1$	7·8 7·8	7·8	Ruddy orange. Bright 8 mag. est.
20	11 10	70	$a+6$; $b-5$ ..	7·4 7·4	7·4	Orange red.
Aug. 27	11 47	70	$b+1$; $c-2$...	8·0 8·0	8·0	Red. 8 mag. est.
31	9 20	70	$b+2$; $c-1$...	8·1 8·1	8·1	Coppery red.
Sept. 21	8 15	70	$b+2$; $c-1$...	8·1 8·1	8·1	Fine red.
Oct. 9	8 55	70	$c+6$; $=e$ ...	8·8 8·8	8·8	Orange red. $8\frac{3}{4}$ est.
1877. Feb. 16	12 10	115	$k+1$ ...	12·7	12·7	5^h from meridian. Clear. $12\frac{3}{4}$ 13 mag.
Mar. 5	11 50	115	$g+3$; $h-3$...	11·6 11·6	11·6	Well seen.
21	11 45	115	$=g$ ...	11·3	11·3	A careful comparison with a out of the field.
Apr. 10	10 20	115	$f+7$; $g-4$...	10·9 10·9	10·9	Slightly ruddy? Sky clouded over.
25	12 0	70	$e+10$; $f-4$	9·8 9·8	9·8	Decidedly ruddy.
May 2	11 15	70	$c+4$; $=d$ ...	8·6 8·6	8·6	Orange red.
4	11 30	70	$c+2$; $d-2$...	8·4 8·4	8·4	Orange red.
7	11 20	70	$=c$ ...	8·2	8·2	Yellow with ruddy cast. Not very decidedly red.
15	11 40	70	$a+8$; $c-6$...	7·6 7·6	7·6	Ruddy yellow.
June 4	11 0	70	$a+2$; $b-9$...	7·0 7·0	7·0	Ruddy orange. Observed in clear intervals between clouds.
9	10 25	70	$a+2$; $b-9$...	7·0 7·0	7·0	Ruddy orange.
20	10 20	70	$a+4$; $b-7$...	7·2 7·2	7·2	Ruddy orange. Moonlight.

S Coronæ Borealis—continued.

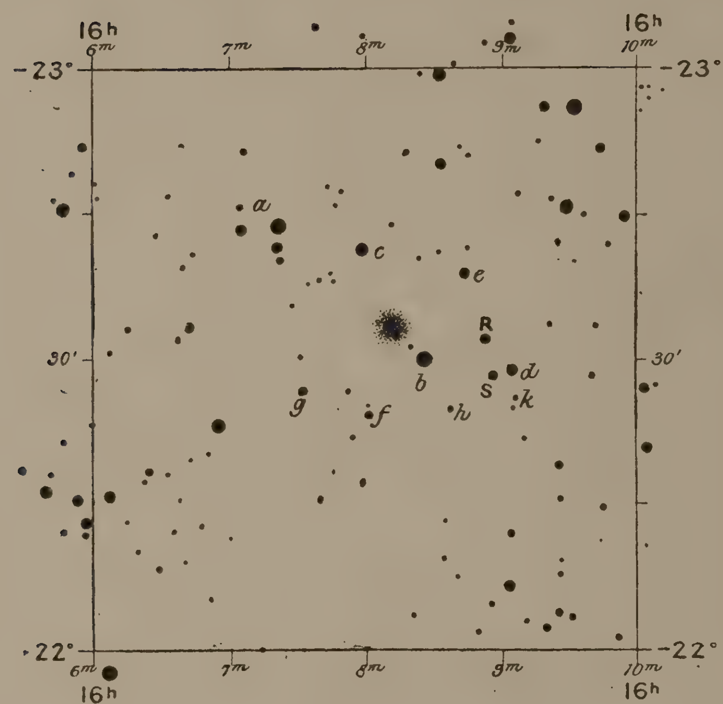
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877. June 23	h m 11 10	70	$a+4$; $b-7$...	7·2 7·2	7·2	Ruddy orange. Decidedly less than *a* by nearly half a magnitude, but *considerably* brighter than *b*.
25	10 55	70	$a+3+4$; $b-7$; $c-10$	7·1 7·2 7·2 7·2	7·2	Ruddy orange. Bright moonlight. Moon near full.
29	11 0	70	$a+4$; $b-7$...	7·2 7·2	7·2	Ruddy orange.
July 7	10 50	70	$a+5$; $b-6$...	7·3 7·3	7·3	Ruddy orange. Decidedly ruddy.
17	11 15	70	$a+7$; $b-3$; $c-7$	7·5 7·6 7·5	7·5	Orange red.
26	10 7	70	$b+1$; $c-2$; $a+12$	8·0 8·0 8·0	8·0	Fine orange red. A decided red.
30	11 5	70	$b+2$; $c-1$...	8·1 8·1	8·1	Full ruddy.
Aug. 2	10 45	70	$b+3$; $=c$ ...	8·2 8·2	8·2	Slightly ruddy.
7	10 20	70	$b+3$; $c-0-1$	8·2 8·2 8·1	8·2	Decidedly ruddy.
14	9 5	70	$c+4$; $=d$ ...	8·6 8·6	8·6	Red. In finder (2-inch ap.) certainly less than *d*. In telescope certainly *not* less than *d*.
17	11 0	70	$=d$; $d+1$?; $c+5$?	8·6 8·7 8·7	8·7	About equal to or rather less than *d*. In finder very decidedly less. Orange red.
Sept. 27	10 15	70 115	$f-4$... ...	9·8	9·8	$9\frac{3}{4}$ est. $7\frac{1}{2}^h$ past meridian and rather hazy.
Oct. 1	8 45	70	$f-2$? ...	10·0	10·0	Hazy. A doubtful observation.
18	6 50	70	$=f$; $f-1$ ...	10·2 10·1	10·15	Ruddy. Abt. 10 mag. est.
1878. Mar. 15	11 5	70	$g+2$; $h-4$...	11·5 11·5	11·5	
		115	$g+3$; $h-3$...	11·6 11·6	11·6	
Apr. 3	9 0	70	$f+5$; $g-6$...	10·7 10·7	10·7	Slightly ruddy?
22	12 15	70	$e+7$; $f-7$ ...	9·5 9·5	9·5	Ruddy. Decided tint.
26	12 0	70	$c+1$; $d-3$...	8·3 8·3	8·3	Ruddy.
May 11	11 0	70	$a+3$; $b-8$...	7·1 7·1	7·1	Decided orange red.
20	11 30	70	$a+2$; $b-9$...	7·0 7·0	7·0	Golden with ruddy flush.
31	11 20	70	$=a$	6·8	6·8	Ruddy orange. In *finder* barely $=a$.
June 6	11 10	70	$=a$	6·8	6·8	*S* and *a* as nearly equal as can be. *S* golden with ruddy flush.
12	11 17	70	$=a$	6·8	6·8	Ruddy orange.
20	11 30	70	$=a$	6·8	6·8	Ruddy orange.
25	11 25	70	$a+2$... ...	7·0	7·0	Ruddy orange.
July 13	10 43	70	$a+3$; $b-8$...	7·1 7·1	7·1	Ruddy orange.
30	10 30	70	$a+11$; $=b$...	7·9 7·9	7·9	Ruddy orange.

S Coronæ Borealis—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1878. Aug. 8	h m 10 40	70	$b+2$; $c-1$ ...	8·1 8·1	8·1	Ruddy.
17	10 45	70	$c+2$; $d-2$...	8·4 8·4	8·4	Clear sky.
Oct. 17	7 45	70 115	$=f$; $f-1$? ...	10·2 10·1?	10·15	5^h 40^m past meridian.
1879 June 9	11 10	70	$a+8$; $c-6$?	7·6 7·6	7·6	Ruddy orange.
1880. Apr. 20	11 10	70	$c+6$; $d+2$; $=e$	8·8 8·8 8·8	8·8	Ruddy orange.
May 12	10 40	70	$a+9$; $b-2$...	7·7 7·7	7·7	Ruddy.
June 7	10 35	70	$a+3$; $b-8$...	7·1 7·1	7·1	Ruddy orange.
25	10 45	70	$a+9+8$; $b-2-3$	7·7 7·6 7·7 7·6	7·65	Ruddy yellow.
1881. May 20	10 37	...	$a-2-3$ ...	6·6 6·5	6·56	6·6 gauged. Has a fine banded spectrum. Orange red.
1882. Aug. 11	10 15	70	$e+7$; $f-7$ ...	9·5 9·5	9·5	Distinctly red.
1883. June 7	10 55	70	$a+6$; $b-5$...	7·4 7·4	7·4	Ruddy orange.
Aug. 24	8 50	70	... ...	...	9·8 ±	Ruddy.
1884. June 30	10 55	70	$=b$; $c-3$ ...	7·9 7·9	7·9	Ruddy orange.
1885. Apr. 6	10 10	70	$=e$	8·8	8·8	Orange red. (Too low? cf. obs. Bax.) Qu. 8·3?
May 11	10 35	70	$a+8$; $b-3$...	7·6 7·6	7·6	Orange red. About $7\frac{1}{2}^m$ est.
June 1	11 10	70	$b+1$; $c-2$...	8·0 8·0	8·0	Orange red. So, too, in finder. A full mag. less than a.
17	10 15	70	$b+3$; $=c$ ...	8·2 8·2	8·2	Ruddy. Fine tint. Qu. $b \sim c > 0·3$?
July 10	10 45	70	$c+4$; $=d$; $e-2$	8·6 8·6 8·6	8·6	Red.
20	10 10	70	$d+2$; $=e$ ...	8·8 8·8	8·8	Ruddy.
1886. June 1	10 30	70	$a+8$; $b-3$...	7·6 7·6	7·6	Orange ruddy.
23	11 35	70	$b+2$; $c-1$...	8·1 8·1	8·1	Ruddy orange.
30	10 26	70	$c-1$... ...	8·1 8·1	8·1	b 4 or 5 $>c$? S ruddy yellow.
July 15	10 40	70	$c+4$; $e-2$...	8·6 8·6	8·6	Full orange red. Fine colour.
Aug. 10	10 45	70	$e+7$; $f-7$...	9·5 9·5	9·5	9·5 ± est. Ruddy.
Sept. 30	8 0	70 115	$f+6$; $g-5$...	10·8 10·8	10·8	Obs. rather doubtful. Hazy.
1887 Apr. 8	10 20	70	$a+1$... ...	6·9	6·9	Orange ruddy. S nearly equal a.
May 10	10 35	70	$a+5$; $b-6$...	7·3 7·3	7·3	Orange ruddy.
1888. Apr. 14	10 37	70	$a-3$... ...	6·5	6·5	Orange ruddy.
May 1	11 15	70	$=a$	6·8	6·8	Fine orange red.
Oct. 23	6 55	70 115	$g+5$; $h-1$...	11·8 11·8	11·8	

Mr. Knott's Diagram, Epoch 1852·5.

R Scorpii.



Magnitudes of Comparison Stars:

$a = 7$	$d = 9·4$	$g = 11·0$
$b = 8·2$	$e = 9·7$	$h = 12·3$
$c = 8·4$	$f = 10·3$	$k = 13·0$

[This diagram is traced from Chacornac's Chart. The declinations do not agree with the figures on opposite page, which seems to be due to an error of 3′ or 4′ in Chacornac's Chart. —H. H. T. Ed.]

R Scorpii.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 5830 *R Scorpii*, R.A. for 1900·0 = $16^h\ 11^m\ 41^s$, Decl. = $-22°\ 41'·9$.

Annual Variation = $+3^s·57$ and $-0'·15$.

R.A. for 1855·0 = $16^h\ 9^m\ 1^s$, Decl. = $-22°\ 35'·0$.

Redness = 0·9. Max. mag. 9·4 – 10·5. Min. < 13.

Maximum, 1863 Mar. 25 = $2401590^d·5$ (Julian).

Period = $224^d·5$. Periodic inequality.

(From twenty-four observations of max., including observations in 1837–53, 63–94.)

Discovered by Chacornac, 1853. Light-curve very variable; marked secondary phases. Increase from 12^m rapid. 8^m pr. 24^s, $2'$ N.; 9^m foll. 10^s, $3'$ N.

R Scorpii.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1864.	h m					
June 30·4		60	$f+2$; $g-1$...	10·5 10·9	10·9	Mr. Pogson's letters.
July 5·4		60	$e+2$; $=f$ ...	9·9 10·3	10·1	Between clouds. Mr. Pogson's Comp. Stars. Neb. 80 *M* as usual.
Aug. 1·3		60	$e+0+1$ ...	9·7 9·8	9·75	*R* very decidedly brighter than *S*.
2		60	$=f$?... ...	10·3	10·3	
1865.						
Apr. 22·5		60	Not seen ...	Below 12 mag	< 12	The neb. as usual.
24		60	Not seen ...	Below 13 mag.	< 13	
25·55		115 micr.	A glimpse object	13·5 13·7	13·6	Fine night.
29·5		102	Not seen ...	Below 12	< 12	Not very clear.
May 15·5		102	Not seen ...	Below 13·5	< 13·5	
22·4		102	Not seen ...	Under 13	< 13	
24·4		...	Not seen ...	Under 13·5	< 13·5	
31·4		60 102	Not seen ...	Under 12·5	< 12·5	Neb. as usual. *S Scorpii* was observed up to end of July, but on no occasion was *R* seen.
1866.						
Apr. 13·5		70	Not seen ...	Under 11·5 or 12	< 11·5 or 12	Neb. as usual. 3[h] fr. meridian.
17·5		70	Tolerably conspicuous	12 12½	12·25	Neb. as usual. Rather far fr. meridian.
23·5		...	... ...	12 ± est.	12 ± est.	Bright moonlight.
May 4·5		70	$k+0+2$ ...	13·0 13·2	13·1	(Is there some mistake here?)
16	10 30	70	$g+0+2$ ...	11·0 11·2	11·1	Neb. as usual.
17·5		70	$g+5$... ...	11·5	11·5	
18·4		70	$g+3$... ...	11·3	11·3	Neb. as usual.
19·4		70	... ...	11·5	11·5	
23·4		70 89	$g+0+2$ ...	11·0 11·2	11·1	Neb. as usual.
June 7·4		70 89	$=h$	12·3	12·3	Bad definition. Haze. Stars not well seen. Neb. as usual.
14·4		70 89	$<h$	12·5?	12·5?	Past max.
16·4		89	Not seen, or glimpsed?	Below 12·5	< 12·5	Less than *h*. Obs. interrupted by clouds. Neb. as usual.
22·4		70 89	Not seen ...	Below 12	< 12	Neb. as usual.
July 9·4		70 89	Not seen ...	Below 12	< 12	Neb. as usual.
1867.						
Apr. 29	12 —	70 89	Not seen ...	Below 13·3	< 13·3	The cluster 80 *M* sparkling. Nothing remarkable about it.
May 3	12 10	115	Not seen ...	Under 13	< 13	Neb. 80 *M* as usual.
7	11 ?	70 89	Not seen ...	...	< 13?	Neb. as usual.
21	10 30	70 89	Not seen ...	Below 11·5	< 11·5	Bad definition and sky not clear.
23	10 45?	70 89	Not seen ...	Below 13·5	< 13·5	Sky clear.
24	12 30	89	Glimpsed? ...	13·5 ± ?	13·5 ±	A very faint object.
28	11 30	89	Not seen ...	Below 13·3	< 13·3	Clear sky.
30	13 30	70	Not seen ..	Below 12·0	< 12·0	Neb. as usual.
June 1	10 30	89 191	$k+2$ ...	13·2	13·2	Neb. as usual.

R Scorpii.—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
June 4	10 30	70 89	Not seen ...	Not above 13	< 13	
10	11 50	89	... ...	12·5 12·7	12·6	Well seen. Neb. as usual.
26	11 0	89	$=f$	10·3	10·3	A bright object. Considerably brighter than *S*. $10\frac{1}{4}$ mag. est. Neb. as usual.
28	10 30	89	$e+3$; $f-2$ ...	10·0 10·1	10·05	Neb. as usual.
July 4	10 15	70 89	$e+4$; $f-1$ ...	10·1 10·2	10·15	Full apert. and also with $4\frac{1}{2}$-inch aperture. Among clouds. Obs. doubtful.
5	11 0	70	$e+3+4$; $f-2-1$	10·0 10·1 10·1 10·2	10·1	$4\frac{1}{2}$-inch aperture. Clear.
8	10 30	70	$e+6$; $=f$ ...	10·3 10·3	10·3	
9	10 30	70	$e+4$; $f-1$ ...	10·1 10·2	10·15	
16	10 40	89	$e+3$; $f-2$ ...	10·0 10·1	10·05	Neb. as usual. Bright moonlight. Moon just full.
27	9 55	70	Barely equal to f?	10·5 ±	10·5 ±	Hazy. Stars 2^h past meridian.
Aug. 2	9 20	89	$d+12$; $e+7$; $f+2+3$; $g-5$	10·6 10·4 10·5 10·6 10·5	10·5	Stars low. 2^h past meridian. Faint twilight. Wind N. by E. Neb. as usual.
9	9 0	89	$<f$	10·5 10·75	10·6	Obs. doubtful. Moon bright and near, and star far from meridian. Neb. as usual. *S* not seen.
20	9 20	89	... ...	11·5 ±	11·5 ±	Very fairly seen. Less than f and g, and est. about $11\frac{1}{2}$ mag. Qu. Is there a rather *hazy* look about it? Neb. as usual. *S* not seen. 3^h 10^m ± past meridian.
1868.						
May 14	11 0	70	Not seen ...	Under 13	< 13	
18	10 45	70 89	Not seen ...	Under 12·3	< 12·3	h seen. Qu. *R* feebly glimpsed at times??
23	10 40	70	Not seen ...	Under 12·5	< 12·5	h well seen. Neb. as usual.
26	10 30	89	Not seen ...	Under 13·5	< 13·5	k seen. Neb. as usual.
27	11 15	89	Not seen ...	Under 12·5	< 12·5	h seen. Neb. as usual.
June 13	10 20	89 191	Not seen ...	Under 13	< 13	
15	11 0	191	Not seen ...	Under 13	< 13	Pretty clear. Neb. as usual.
17	10 55	89	Not seen $<k$	Under 13	< 13	Nebula as usual.
23	11 10	191	Not seen ...	Under 13	< 13	Neb. as usual; but qu. is there a brightish speck near centre? The nebulax seems to glitter (sparkle).
29	10 40	89	Not seen ...	Under 11	< 11	Moonlight troublesome. Neb. as usual.
July 13	10 20	89	Not seen ...	Under 11·5	< 11·5	Neb. as usual.
20	9 55	89	Not seen ...	Under 12	< 12	h glimpsed.
Aug. 8	9 5	89	Not seen ...	Under 11	< 11	f 10·3 well seen. No trace of *R* or *S*. Neb. as usual. 2^h past meridian, but clear.
1869.						
June 15	10 40	89	$g+8$; $h-5$ ...	11·8 11·8	11·8	Obs. a little doubtful.

R Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869.	h m					
July 3	10 15	70 191	Not seen ...	Under 10	< 10·0	Neb. 80 *M* as usual. Haze and twilight.
10	10 25	89	Not seen ...	Under 10·5	< 10·5	*f* clearly seen. Hazy. Nebula as usual.
Aug. 12	8 50	89	Not seen ...	Under 10·3	< 10·3	*f* seen. Nebula as usual.
1870.						
Apr. 25	11 45	89 191	Not seen ...	Under 13	< 13	
May 2	11 30	89 191	Not seen ...	Under 12	< 12	Neb. as usual.
7	10 35	89 191	Not seen ...	Under 12	< 12	Slight haze and moonlight.
16	10 35	89	Not seen ...	...	...	
June 6	10 30	89	Not seen ...	Under 12·5	< 12·5	Moonlight and haze. Neb. as usual.
20	11 45	89	Not seen ...	Under 12	< 12	Neb. as usual. *h* seen by glimpses.
1871.						
May 17	11 10	89	Not seen ...	Under 13	< 13	Vision rather unsteady.
22	11 10	89	Not seen ...	Under 13	< 13	
23	11 30	156	Not seen ...	Under 13	< 13	
June 5	10 40	156	Not seen ...	Under 13	< 13	Neb. bright as usual.
1872.						
May 15	10 30	115	$f+1+2$ ...	10·4 10·5	10·45	10½ est.
27	12 10	70 115	$f+1$... ...	10·4	10·4	
June 13	10 25	115	About $=g$?...	11·0	11·0	11 mag. est. Haze so troublesome that no value attaches to the observation.
29	10 30	70 115	... ...	...	11¼ est.	Rather less than *g*. Hazy.
July 9	10 5	70	... ...	...	...	Lost in cloud and haze. Qu. *R* glimpsed? Not > 11.
1877.						
Mar. 30	14 0	115	Not seen ...	Under 9·7	...	I do not see either *R* or *S*, but field flooded with moonlight and oppressed with cloud and haze. Certainly neither is so bright as either *d* or *e*, which are well seen. Neb. 80 *M* faint but as usual.
Apr. 25	12 30	115	$f+3+2$; $g-4-5$; $e+9+8$	10·6 10·5 10·6 10·5 10·6 10·5	10·55	About 10½ mag. est. Bright moonlight. Neb. 80 *M* as usual.
May 4	11 20	115	$e+6$; $=f$ ...	10·3 10·3	10·3	Est. about 10 mag. Neb. 80 *M* as usual.
7	11 40	115	$=f$	10·3	10·3	Neb. 80 *M* as usual. *S* not seen (under 13. *k* seen), but qu. glimpsed??? Very doubtful.
15	11 50	115	$f+3$; $g-4$...	10·6 10·6	10·6	Obs. a little doubtful.
June 4	10 35	115	$g+2$? $\frac{1}{2}(f+8)$	11·2 11·3	11·25	Clear. Among clouds. Neb. as usual.
9	10 15	89 115	$f+12$; $g+5$; $h-8$	11·5 11·5 11·5	11·5	Observation difficult. Nebula as usual. *S* not seen. Under 12½ mag.
25	11 30	191	Not seen ...	$<g$	< 11·0	Under 11 mag. *g* seen. *R* not seen, lost in bright moonlight and haze. *S* not seen. Neb. as usual.

R Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduc d Mags.	Mean Mag.	Remarks.
1877. June 29	h m 11 25	115	$=k$	13·0	13·0	A glimpse object. Neb. as usual.
July 26	10 0	115	Not seen ...	Certainly < 11	< 11	*g* pretty well seen and small ✱ to south of it. *h* not seen.
Aug. 7	10 0	70 115	Not seen ...	...	...	
1878. Apr. 22	12 30	115	Not seen ...	Under 11 or $11\frac{1}{2}$	< 11 or $11\frac{1}{2}$	*g* well seen. *h* not seen. Neb. as usual. Haze and cloud.
May 20	11 15	70 115	Not seen ...	Under 11	< 11	*g* seen. *h* not seen. Neb. 80 *M* as usual, glittering, resolved? Obs. very troublesome from clouds, which closed the obsn.
21	10 30	115	Not seen ...	Under 10·5	< 10·5	*f* seen. Cloudy. Neb. as usual.
	11 35	115 191	Not seen ...	Under 13·5?	< 13·5?	Clear now. *S* glimpsed. $13\frac{1}{2}$?
25	11 10	70 115 191	Not seen ...	Under 12·5	< 12·5	*h* well seen. But qu. are both *R* and *S* feebly glimpsed at times? If so not > 13 or $13\frac{1}{2}$. Neb. as usual. Not quite clear sky.
31	11 10	115	Not seen ...	Under 11	< 11	*f* and *g* seen. *h* not seen. Hazy. Neb. as usual.
June 6	11 0	191	Not seen ...	Under 13?	< 13?	Rather hazy.
7	11 0	89	Not seen ...	...	...	
20	10 50	115	$h+5$; $k-2$?	12·8 12·8	12·8	13 mag. ± est. Neb. as usual. A clear sky.
25	11 0	115	$=h$	12·3	12·3	Neb. as usual. A little hazy.
July 13	10 30	115	$e+2$; $f-4$ ...	9·9 9·9	9·9	A bright 10 mag. est. Obs. of this star and of *S* difficult and a little doubtful. Moonlight and haze troublesome. *f* not very well seen.
30	10 15	70 115	$d+4$; $e+1$; $f-5$	9·8 9·8 9·8	9·8	Neb. 80 *M* as usual. Vision rather confused and obs. troublesome.
Aug. 1	10 25	89	$d+3+4$; $e-1-0$?	9·7 9·8 9·8 9·7	9·75	Obs. very difficult. Star 3h past meridian and not very clear sky.
8	9 0	191	$d+3$; $=e$ ...	9·7 9·7	9·7	Obs. difficult. 2h past meridian and Moon bright. Neb. 80 *M* as usual.
17	8 45	70 89 115	$d+5$; $e+2$; $f-4$	9·9 9·9 9·9	9·9	Clear, but 2h past meridian. Neb. 80 *M* as usual.
1879. May 21	11 15	89	Glimpsed ...	$13\frac{1}{2}$	13·5	Less than *k*, wh. fairly seen. Neb. as usual.
June 9	10 30	191	Not certainly seen	< 13?	< 13?	Qu. glimpsed?? Neb. 80 *M* as usual.
July 23	9 50	115	Not seen ...	...	...	Neb. 80 *M* as usual. Rising mist and cloud interrupted obs.
24	9 55	115	Not seen ...	Under 12?	< 12?	Neb. as usual. *k* not seen. *h* not seen very steadily.
Aug. 11	9 25	115	*Not seen* ...	Under 12	< 12	Certainly not so bright as *g*. Not so bright as *h*? *h* glimpsed at times. Neb. as usual.
1880. Apr. 20	11 48	115	Not seen ...	Under 10·3	< 10·3	*e* and *f* seen. Neb. as usual. $2\frac{1}{2}$h from meridian. Not very clear.

R Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1880.	h m					
May 1	10 55	115	$g+5$; $h-8$...	11·5 11·5	11·5	Neb. 80 *M* as usual. Stars low and badly seen.
8	10 45	115	$g+3$; $h-10$	11·3 11·3	11·3	$11\frac{1}{4}$ $11\frac{1}{2}$ est. Neb. 80 *M* as usual.
12	10 15	115	$g+3$? ...	11·3?	11·3?	Neb. 80 *M* as usual. Doubtful.
17	10 20	115 191	$f+5+4$; $g-2-3$	10·8 10·7 10·8 10·7	10·75	Neb. 80 *M* as usual.
28	10 15	115	$e+6$; $=f$ ...	10·3 10·3	10·3	Neb. 80 *M* as usual. Bright and glistening.
June 7	10 15	115	$e+2$; $f-4$...	9·9 9·9	9·9	Neb. 80 *M* as usual.
25	10 30	115	$e+4$; $f-2$...	10·1 10·1	10·1	Observation doubtful. Hazy. Neb. as usual.
July 29	9 50	115 156 191	$=h$	12·3	12·3	12·0 12·3 est. Obs. difficult. Neb. 80 *M* as usual.
Aug. 10	9 10	115	Not seen. Under f	Under 10·3	< 10·3	Neb. 80 *M* as usual. Hazy.
1881.						
Mar. 29	14 55	115	Glimpsed ...	13·5?	13·5?	*h* and *k* seen. Neb. 80 *M* as usual.
May 8	12 50	115	Not seen ...	Under 13	< 13·0	
20	10 0	115	Not seen ...	Under $12\frac{1}{2}$	< $12\frac{1}{2}$	
30	10 0	70 115	Not seen ...	...	...	
June 23	11 0	70	Not seen ..	...	...	
July 4	10 16	70 115	Not seen ...	...	...	
Aug. 10	9 0	70 115	Not seen ...	Under f	< 10·3	
1882.						
May 11	11 30	70 115	$e+3$; $f-3$...	10·0 10·0	10·0	Neb. 80 *M* as usual.
15	10 45	115	$e+3$; $f-3$...	10·0 10·0	10·0	Neb. 80 *M* as usual.
18	11 35	70	$\frac{1}{2}(e+f)$ ...	10·0	10·0	*R* and *S* equal? Neb. 80 *M* as usual.
20	10 35	115	$=f$?; $f-1$?	10·3? 10·2?	10·25?	Neb. 80 *M* as usual. Clear, but definition bad, with east wind.
June 7	11 0	70	Not seen, or qu. once glimpsed?	...	Glimps'd?	Difficult obs. in clear intervals between clouds.
12	10 10	115	Not seen ...	Under 12	< 12	*h* glimpsed. Neb. 80 *M* as usual.
15	10 15	115	Not seen ...	...	...	
July 24	9 45	115	Not seen ...	...	...	Sky not clear, and Moon rather near.
Aug. 7	9 50	70	Not seen ...	...	Under 11	Neb. 80 *M* as usual.
1883.						
May 15	10 20	115	Not seen ...	...	...	
31	10 45	110	Not seen ...	Less than 13	< 13	Neb. 80 *M* as usual.
June 1	10 50	115	Glimpsed	13 $13\frac{1}{2}$?	13·25?	Neb. 80 *M* as usual.
15	10 45	115	... ...	11·5 ±	11·5 ±	Hardly $=g$; $-11\frac{1}{4}$ $11\frac{1}{2}$. *S* not seen. *h* not seen. 80 *M* as usual. *R* about $11^{m}·5$; not brighter, I think. Obs. difficult.
25	10 57	115	$f+5$; $g-2$...	10·8 10·8	10·8	Rather doubtful obs. *R* about 11 mag. Neb. 80 *M* as usual. *S* not seen.

R Scorpii—continued.

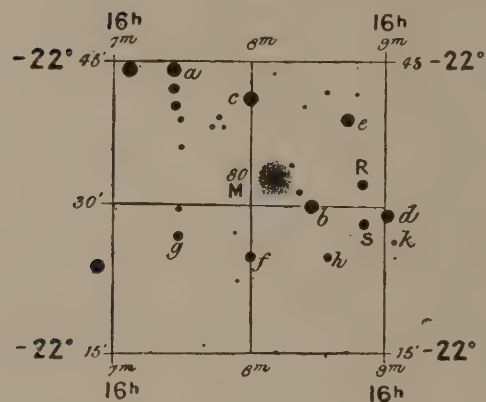
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1883. June 28	h m 10 30	70 110	$f-1$	10·2	10·2	Neb. 80 *M* as usual.
30	10 50	70	$f-0-1$ ...	10·3 10·2	10·25	Full aperture, and one of 3 inches. Neb. 80 *M* as usual.
July 4	10 0	70 115	$f-2-1$ ...	10·1 10·2	10·15	Neb. 80 *M* as usual.
13	10 32	70 115	$e+3$; $f-1$ ...	10·0 10·2	10·1	Neb. 80 *M* as usual.
28	9 50	115	$f+4$; $g-3$...	10·7 10·7	10·7	Neb. 80 *M* as usual. Before this observation tried to catch *S Virginis* but cloud-band low down, too thick to allow of its being seen at all.
Aug. 21	8 45	115	Not seen ...	Under 11½?	< 11½	*g* seen. Neb. 80 *M* as usual. *S* not seen.
1884. June 30	10 23	70 115 110	Neither *R* nor *S* seen	Under 11½	< 11½	Neither *R* nor *S* seen. *f* and *g* seen. *h* not seen. *f* hardly so bright as 10·3? Neb. 80 *M* as usual.
1885. Feb. 21	4 40	115	Not seen ...	Under 12?	< 12?	Neither *R* nor *S* seen. Under 12? *g* well seen. *h* glimpsed. Neb. 80 *M* as usual.
May 11	11 15	110 70	$d+3$; $=e$ ...	9·7 9·7	9·7	Neb. 80 *M* as usual. Rather hazy. Obs. a little doubtful.
15	10 45	70 110	$e+3$; $f-3$ ...	10·0 10·0	10·0	Neb. 80 *M* as usual.
June 1	10 50	110	About $=f$ ...	10·3	10·3 ±	Hazy. Neb. 80 *M* as usual.
17	10 25	115	$=g$	11·0	11·0	Hazy sky. *R* seen, abt. 11 mag. *S* *not* seen. Neb. 80 *M* as usual.
July 10	10 16	110	... ...	13	13	Some tenths less than *h*, which is well seen. *k* glimpsed also. *S* not seen. Neb. 80 *M* as usual. Clear sky.
1886. June 1	10 20	115 200	Not seen ...	Under 12½ 13	< 12¾	*h* seen. *k* glimpsed. Neb. as usual. glittering.
23	11 25	115	$g+8$; $h-5$...	11·8 11·8	11·8	12 mag. est. *S* not seen. Neb. 80 *M* as usual. Rather bright centre?
30	10 16	115	$f+7$; $=g$; $h-13$	11·0 11·0 11·0	11·0	Neb. 80 *M* as usual. *S* not seen. Under 12½.
July 1	10 30	115	$f+4$; $g-3$...	10·7 10·7	10·7	Neb. 80 *M* as usual, but qu. with 200, brightish knot about centre?
5	10 30	70 115	$e+6$; $f-0$...	10·3 10·3	10·3	Neb. 80 *M* as usual. Brightish knot, slightly preceding centre. *S* not seen. Under 11·12? *h* not seen.
15	10 30	115	$d+5$; $e+2$; $f-4$	9·9 9·9 9·9	9·9	Moonlight and sky hazy, so obs. made with difficulty. Neb. 80 *M* as usual.
24	10 20	70	$d+4$; $e+1$...	9·8 9·8	9·8	Observed with difficulty among clouds. Neb. 80 *M* as usual.
Aug. 10	8 45	115	$d+6$; $e+3$; $f-3$	10·0 10·0 10·0	10·0	Observed with difficulty. Twilight and moonlight. Neb. 80 *M* as usual.

R Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1886 Aug. 10	h m 8 55	115	$d+7$; $e+4$; $f-2$	10·1 10·1 10·1	10·1	Vision a little clearer. Perhaps these last estimates more correct than the preceding. *R* certainly *brighter* than *f*. 80 *M* rather faint but distinctly seen.
1887. May 20	10 25	70 115	Not seen ...	Under 10·3	< 10·3	*f* seen. Neb. 80 *M* as usual.
June 13	10 15	115	Not seen ...	Under 12·3	< 12·3	*h* glimpsed at times. Neb. 80 *M* as usual.
18	10 50	115	Not seen ...	Under 12½	< 12½	Neb. 80 *M* as usual. Glittering as a star mass.
30	10 30	115	Not seen ...	Under 11·12	< 11·12	*g* well seen. *h* not seen. Neb. 80 *M* as usual.
July 19	10 23	115	Not seen ...	Under 12·3	< 12·3	*h* seen fairly at times. Neb. 80 *M* as usual.
21	10 37	115	Not seen ...	Under 12·3	< 12·3	*h* seen well. Neb. 80 *M* as usual.
1888. May 1	11 0	110	... ...	11·8	11·8	*f*, *g*, *h* seen. *k*? Neb. 80 *M* as usual.
3	11 15	115	... ...	11·8 est.	11·8 est.	Neb. 80 *M* as usual.
10	11 5	70 110	$f+4$; $g-3$...	10·7 10·7	10·7	Neb. 80 *M* as usual. Sparkles as cluster.
12	10 50	115	$f+2$... ...	10·5	10·5	Neb. 80 *M* as usual.
23	10 40	70 115	$d+4$... ...	9·8	9·8	About 10·0 mag. Neb. 80 *M* as usual, but obs. difficult. Haze and moonlight.
Aug. 8	9 10	115 191	Not seen ...	Under 12	< 12	*h* seen at times. Neb. 80 *M* as usual.
13	9 0	115	Not seen ...	Under 12	< 12	*h* glimpsed. Neb. 80 *M* as usual.
1889 June 3	10 45	115	Not seen ...	Under 12	< 12	*h* seen. Neb. 80 *M* as usual.
Aug. 7	8 55	115	$e+1$; $f-5$...	9·8 9·8	9·8	*R* and *S* both visible in hazy sky. Moon rather near. Neb. 80 *M* as usual.
1890. June 9	10 20	115	Not seen ...	Under 13	< 13	*h* and *k* seen. Neb. 80 *M* as usual.
Aug. 1	9 50	70 115	Not seen ...	Under 10	< 10	2^h 20^m past meridian. Vision unsteady. Neb. 80 *M* as usual.
27	8 45	115	Not seen ...	...	...	*d* seen. Stars 3^h past meridian and sky light. Neb. 80 *M* as usual.
1891. June 5	10 30	70 115	$f+5$; $g-2$...	10·8 10·8	10·8	Neb. 80 *M* possibly, with bright nipple near centre.
July 28	10 7	115	$g+5$... ...	11·5	11·5	
Aug. 12	9 45	115	Not seen ...	Under 10½?	< 10·5?	Neb. 80 *M* as usual. Obs. altogether doubtful.

Mr. Knott's Diagram, Epoch 1852·5.

R and S Scorpii.



Approximate Magnitudes of Comparison Stars :

$a = 7$	$d = 9·4$	$g = 11·0$
$b = 8·2$	$e = 9·7$	$h = 12·3$
$c = 8·4$	$f = 10·3$	$k = 13·0$

The star *d* is the star observed for *S Scorpii* in the Greenwich Observations, 1861.

[This diagram is traced from Chacornac's Chart. The declinations do not agree with the figures on opposite page. Chacornac's Chart seems to be several minutes of arc in error. —H. H. T. Ed.]

S Scorpii.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 5831 *S Scorpii*, R.A. for 1900·0=$16^h\ 11^m\ 42^s$, Decl. =$-22°\ 39'·0$.

Annual Variation $+3^s·57$ and $-0'·15$.

R.A. for 1855=$16^h\ 9^m\ 2^s$, Decl. =$-22°\ 32'·0$.

Redness=0. Max. mag.=9·1−10·5. Min. <13.

Maximum, 1837 June 1=$2392162^d·4$ (Julian).

Period=$+176^d·7$.

(From 26 observations of max., including observations in 1837, 39, 54–95.)

Discovered by CHACORNAC, 1854. $9^m·4$ foll. 9^s, $0'·2$ N.

S Scorpii.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1864.	h m					
June 30.4		60	$d+2$; $e-1$...	9.6 9.6	9.6	$S>R$.
July 5.4		60	$d+3$ ...	9.7	9.7	The nebula 80 *M* appears as usual.
Aug. 1.3		60	Less than g...	$<$11.0	$<$11.0	
2		60	$=g$?... ...	11.0?	11.0?	
1865.						
Apr. 22.5		60	Not seen ...	Under 12	$<$12	The neb. as usual.
24.4		60	Not seen ...	Under 13	$<$13	The neb. as usual.
25.6		115	Not seen ...	Under 13.7	$<$13.7	A fine night.
29.5		102	Not seen ...	Under 12	$<$12	Not very clear.
May 6.5		60	Not seen ...	Under 12	$<$12	
15.5		102	$=k$	13.0	13.0	Est. 13.1.
16.4		102	$k-0-1$ ...	13.0 12.9	12.95	Gauged 12.9 mag.
22.4		102	... ...	12.5 12.7	12.6	Hazy. Not well seen.
24.4		102	$=h$	12.3	12.3	
25.4		102	$=h$	12.3	12.3	
31.4		60 102	$g+8$; $h-4$...	11.8 11.9	11.85	12.0 est. Hazy?
June 6.4		102	... ...	10.8?	10.8?	Bright moonlight. Stars obsd. with great difficulty.
7.4		102	Rather less than f	10.5 ±	10.5 ±	Moon near. Obs. very uncertain.
16.4		102	$d+2+3$ ...	9.6 9.7	9.65	Fair observation.
19.4		...	$d+2$; $=e$; $f-3-4$	9.6 9.7 10.0 9.9	9.8	
21.4		115	$d+2$ ...	9.6	9.6	
27.4		115	$=d$; $d+1$ ...	9.4 9.5	9.45	Rather hazy.
July 3.4		115	$d+2+3$ ...	9.5 9.6	9.55	Fair obs. Wire micrometer.
11.4		60	$d+6+7$; $e+3$ $=f$	10.0 10.1 10.0 10.3	10.1	Evidently past maximum. Moonlight.
12.4		60	$e+4$; $f+1$...	10.1 10.4	10.25	2h past meridian. Not well seen.
15.4		60	$d+7+8$ ...	10.1 10.2	10.15	2h past meridian. Fairly seen.
25.4		60	... ...	11.5?	11.5?	Decidedly $<g$. h not seen. Too far from meridian and not clear.
26.4		60 102	$g+3$? ...	11.3?	11.3?	Hazy. 2h past meridian. Certainly $<g$.
1866.						
Apr. 13.5		70	Not seen ...	Below 11.5 or 12	$<$11.5 or 12	3h from meridian. 80 *M* as usual. Clouds came up.
17.5		70	Not seen ...	Below 13	$<$13	
23.5		70	Not seen ...	Below 12.5	$<$12.5	
May 4.5		70	A glimpse object	13.0 13.3	13.15	
16.4		70	$h+0+2$ ...	12.3 12.5	12.4	
17.5		70	... ...	12.5 ±	12.5 ±	
18.4		70	$=h$? ...	12.3	12.3	

S Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866.	h m					
May 19·4		70	... ...	12·5	12·5	
23·4		70 89	$h-3-5$ ...	12·0 11·8	11·9	
June 7·5		70 89	$f+4$; $g-5$...	10·7 10·5	10·6	Bad definition. Haze. Stars not well seen. Neb. as usual.
14·4		70 89	$d+6$; $f-3$...	10·0 10·0	10·0	The neb. as usual.
16·4		60 89	$d+10$; $f+1+2$	10·4 10·4 10·5	10·4	The neb. as usual. Obs. interrupted by clouds.
22·4		70 89	$d+10+12$; $f+1+2$	10·4 10·6 10·4 10·5	10·5	Moonlight. The neb. as usual.
July 9·4		70 89	... ...	11·5 est.	11·5 est.	Bad defn. The nebula as usual.
1867. Apr. 29	12 —	70 89	... ...	12·8 13·0	12·9	The neb. 80 *M* sparkling. Nothing remarkable about it.
May 3	12 10	115	... ...	12¾	12·75	
7	10 30±	70 89	... ...	12·0	12·0	Neb. as usual.
21	10 30	70 89	$d+5+6$; $f-3-4$	9·9 10·0 10·0 9·9	9·95	Neb. as usual.
23	10 30±	70 89	$d+4$; $=e$; $f-5$	9·8 9·7 9·8	9·8	Neb. as usual.
24	12 30	70 89	$d+2$; $e-2$...	9·6 9·5	9·55	Neb. as usual.
28	11 30	70	$d+1$ ...	9·5	9·5	Neb. as usual.
30	13 30	70	$d+1+2$ ...	9·5 9·6	9·55	
June 1	10 30	70	$d+2$; $e-2$...	9·6 9·5	9·55	Neb. as usual.
4	10 30	70 89	$d+2$... ...	9·6	9·6	Neb. as usual.
7	10 0	70	$d+2$; $e-2$?	9·6 9·5	9·55	Among clouds.
10	11 50	89	$d+5$; $e+1+2$; $f-3$	9·9 9·8 9·9 10·0	9·9	Neb. as usual. 4½-inch aperture.
26	11 0	89	$=g$	11·0	11·0	10 8± est.
28	10 30	89	$f+6$; $g-1$...	10·9 10·9	10 9	Vision rather unsteady.
July 4	10 15	70 89	... ...	11¼ 11½ est.	11·4	Doubtful. Clouds troublesome. Neb. as usual.
5	11 0	70	... ...	11·3 11·5±	11·4±	Neb. as usual. A brilliant central condensation with a fainter surrounding nebulosity.
8	10 30	191	... ...	12·5±	12·5±	Neb. as usual. Hazy.
9	10 30	191	... ...	12·25±	12·25±	Obs. not easy. *S* about equal to *h*.
16	10 40	89	Not seen ...	...	...	Faint stars lost in bright moonlight.
29	10 —	70	Not seen ...	Below 11·5	< 11·5	Neb. as usual.
Aug. 2	9 20	89	Not seen ...	Below 12	< 12	
9	9 —	89	Not seen ...	...	...	
20	9 20	89	Not seen ...	...	...	
1868. May 14	11 15	70	$d+3$; $e-1$...	9·7 9·6	9·65	Neb. as usual.
18	10 45	70 89	$d+2$; $e-1$...	9·6 9·6	9 6	Neb. as usual.
23	10 30	70	$d+3$; $e-2$?	9·7 9·5(?)	9·6?	4-inch aperture. Slight haze and cloud.

S Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1868. May 26	h m 10 30	60	$d+4$; $e+1$; $f-5$	9·8 9·8 9·8	9·8	Full aperture. Sky tolerably clear. Definition not good.
27	11 15	70 89	$d+3$; $=e$ ...	9·7 9·7	9·7	Sky rather hazy.
June 13	10 20	70 89	$f+7$; $=g$ ...	11·0 11·0	11·0	Rather hazy. Neb. as usual.
15	11 5	70 89	$g+9$; $h-4$...	11·9 11·9	11·9	
17	11 0	89	$g+9$; $h-4$...	11·9 11·9	11·9	Haze about.
23	11 10	191	... ...	12¾ est.	12·75	Bad definition, but clear.
29	10 40	89	Not seen ...	Under 11	< 11	Moonlight troublesome. Neb. as usual.
July 13	10 20	89	Not seen ...	Under 11·5	< 11·5	Neb. as usual.
20	9 55	89	Not seen ...	Under 12	< 12	Neb. as usual.
Aug. 8	9 5	89	Not seen ...	Under 11 ?	< 11 ?	f well seen. No trace of R or S. Nebula as usual. 2^h past meridian, but clear.
1869. June 15	10 40	89	Not seen ...	Under 12·5	< 12·5	Neb. as usual.
July 3	10 15	70 191	Not seen ...	Under 10	< 10·0	Neb. as usual. Haze and twilight.
10	10 25	89	Not seen ...	Under 10·5	< 10·5	f clearly seen. Hazy. Neb. 80 M as usual.
Aug. 12	8 50	89	Not seen ...	Under 10·3	< 10·3	f seen. Neb. as usual.
1870. Apr. 25	11 45	89 191	$=g$	11·0	11·0	Neb. 80 M as usual.
May 2	11 25	89 191	$=g$?... ...	11·0 ±	11·0 ±	Rather doubtful. Vision unsteady. I think not brighter than g. Neb. as usual.
7	10 30	89	$f+7$?; $=g$?	11·0? 11·0?	11·0 ?	Not much change, I think, since last observed. Neb. as usual.
16	10 35	89	10½ or 11 mag. ?	10·5 or 11 est.	10¾ est.	Bright moonlight. Moon bright and near. Neb. as usual. R not seen.
June 6	10 30	89	... ...	12·5 est.	12·5 est.	Not well seen. Moonlight and haze. Neb. as usual.
20	11 45	89	Not seen ...	Under 12	< 12	Neb. as usual. h seen by glimpses.
1871. May 17	11 10	89	$h-3$... ...	12·0	12·0	12 ± est. Neb. as usual. Vision rather unsteady.
22	11 10	89	$h+5$; $k-2$...	12·8 12·8	12·8	Definition execrable, but sky very clear at times. Wind N.E. Neb. as usual.
23	11 30	156	$h+4$; $k-3$...	12·7 12·7	12·7	12¾ est. Neb. as usual.
June 5	10 40	156	Not seen ...	Under 13	< 13	Neb. 80 M bright. As usual.
1872. May 15	10 30	115	Not seen ...	Under 12 ?	< 12 ?	Obs. difficult. Haze and moonlight. Neb. 80 M as usual.
27	12 10	70 115	Not seen ...	Under 12 ?	< 12 ?	Neb. 80 M as usual.
June 13	10 25	115	Not seen ...	...	< 12 ?	Neb. 80 M as usual.
29	10 20	70 115	Not seen ...	Under 12·3	< 12·3	h seen. Neb. as usual.
July 9	10 5	70	Not seen ..	...	...	Lost in cloud and haze.

S Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877.	h m					
Mar. 30	14 0	115	... ...	...	...	I do not see either *R* or *S*, but field flooded with moonlight and oppressed with cloud and haze. Certainly neither is so bright as either *d* or *e*, which are both well seen. Nebula faint, but as usual.
Apr. 25	12 35	115	Not seen ...	Under 12 ?	< 12 ?	Certainly under 11·5, probably under 12. *h* doubtfully glimpsed.
May 4	11 20	115 191	Not seen ...	Under 13	< 13	*k* seen.
7	11 40	115 191	Not seen ...	Under 13	< 13	*k* seen. But qu. glimpsed ? ? ? *Very doubtful.*
15	11 55	115	Not seen ...	Under 12·3	< 12·3	*h* seen. Nebula as usual.
June 4	10 40	115	Not seen ...	Under 13	< 13	*k* well seen. Neb. 80 *M* as usual.
9	10 15	89 115	Not seen ...	Under 12½	< 12½	
25	11 30	191	Not seen ...	Under 11 mag.	< 11	Moonlight and haze.
29	11 25	115	$=h$; $h-$? ...	12·3	12·3	About 12 mag. est. Sky clear.
July 26	10 0	115	$d+3$; $=e$; $f-6$	9·7 9·7 9·7	9·7	Obs. a little doubtful. 2ʰ past meridian and not very clear. Nebula as usual.
30	10 30	115	$d+3$; $=e$; $f-6$	9·7 9·7 9·7	9·7	Fair obs., but rather far from meridian, and vision rather disturbed. Nebula as usual.
Aug. 2	10 25	70 115	$d+3$; $=e$ ...	9·7 9·7	9·7	Nebula 80 *M* as usual.
7	10 0	70 115	$e+3$; $f-3$ ...	10·0 10·0	10·0	3ʰ past meridian. Clear, but air disturbed after a wet day. Neb. as usual. *R* not seen.
15	8 40	70	$e+6$; $=f$?...	10·3 10·3	10·3	A doubtful observation. Clouds troublesome. Certainly not, I think, less than *f*.
1878.						
Apr. 22	12 30	115	Not seen ...	Under 11	< 11	Neither *R* nor *S* seen. Under 11 or 11½. *g* well seen. *h* not seen. Neb. 80 *M* as usual. Haze and cloud.
May 20	11 15	70 115	Not seen ...	Under 11	< 11	*g* seen, *h* not seen. Nebula 80 *M* as usual, glittering, resolved? Obs. very troublesome from clouds, which closed the obs.
21	10 30	115	Not seen ...	Under 10½	< 10·5	*f* seen. Cloudy. Neb. as usual. Obs. interrupted by clouds.
	11 35	115 191	Glimpsed ...	13½ ?	13·5 ?	Clear now. Neb. as usual. *R* not seen.
25	11 10	70 115 191	Not seen ...	...	< 12·5	*h* well seen. But qu. both *R* and *S* feebly glimpsed at times? If so, not > 13 − 13½. Neb. as usual. Not quite clear sky.
31	11 10	115	Not seen ...	Under 11	< 11	*f* and *g* seen. *h* not seen. Hazy. Nebula as usual.
June 6	10 50	191	$h+3+4$; $k-3$	12·6 12·7 12·7	12·7	12¾ est. Rather hazy, but *S*, *h*, and *k* well seen at times. Nebula 80 *M* as usual.
7	11 0	89	Glimpsed once or twice very doubtfully	...	...	Haze very troublesome. Neb. as usual. *R* not seen.

S Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1878. June 20	h m 10 45	115	$f+10$; $g+3$; $h-10$	11·3 11·3 11·3	11·3	A clear sky. Neb. as usual.
25	11 0	115	$f+6$; $g-1$...	10·9 10·9	10·9	Nebula as usual. A little hazy.
July 13	10 30	115	$d+3$; $=e$ ...	9·7 9·7	9·7	Observation difficult on account of bright moonlight and haze. Neb. 80 *M* as usual.
30	10 20	115	$f+4$; $g-3$...	10·7 10·7	10·7	Pretty clear, but confused vision. $2\frac{3}{4}^h$ past meridian.
Aug. 1	10 30	89	$f+4$; $g-3$?	10·7 10·7	10·7	Neb. 80 *M* as usual. Obs. difficult and uncertain.
8	9 5	191	$f+5$? ...	10·8	10·8	$10\frac{3}{4}$ mag.? Obs. very doubtful. Considerably less than *f*.
17	8 50	89 115	... ...	$11\frac{3}{4}$ 12 est.	11·9	Seen at times with a little difficulty. Considerably less than *g*, but brighter than *h*.
	9 0	191	... ...	12 est.	12·0	Not brighter than 12 mag., I think. I doubt whether it is more easily seen than *h*.
1879. May 21	11 15	89	Not seen ...	Under $13\frac{1}{2}$?	$<13\frac{1}{2}$?	Neb. 80 *M* as usual.
June 9	10 30	191	$=k$?... ...	13·0?	13·0?	Hazy and definition very bad. Neb. 80 *M* as usual.
July 23	9 50	115	Not seen ...	...	...	Rising mist and cloud interrupted obs. *d* seen.
" 24	9 55	115	$g+8$; $h-5$...	11·8 11·8	11·8	Bright 12 mag. est. Neb. as usual. *R* not seen. *k* not seen. *h* not seen very steadily.
Aug. 11	9 25	115	Not seen ...	Under 12	<12	Certainly not so bright as *g*. Not so bright as *h*? *h* glimpsed at times. Neb. as usual.
1880. Apr. 20	11 40	115	Not seen ...	Under 10·3	$<10·3$	*e* and *f* seen. Neb. as usual. $2\frac{1}{2}^h$ from meridian. Not very clear.
May 1	10 55	115	Not seen ...	Under 12·5	$<12·5$	Neb. as usual.
8	10 45	115	Not seen ...	Under 12·5	$<12·5$	Neb. as usual. *h* seen pretty well.
12	10 15	115	Not seen ...	Under 12	<12	Not seen. *h* not seen. Neb. 80 *M* as usual.
17	10 25	191	$h+2+3$ ...	12·5 12·6	12·55	Neb. 80 *M* as usual.
28	10 15	115	$g+8$; $h-5$...	11·8 11·8	11·8	Neb. 80 *M* as usual. Bright and glistening.
June 7	10 15	115	$g+4$; $h-9$...	11·4 11·4	11·4	Rather hazy? Neb. 80 *M* as usual.
25	10 35	115	$g+0+1$; $h-13-12$	11·0 11·1 11·0 11·1	11·05	*S* about 10 > *R*. Neb. as usual.
July 29	9 50	115	... ...	$12\frac{3}{4}$ 13 est.	12·9	A glimpse object. Stars low. Haze troublesome and observation doubtful and difficult.
Aug. 10	9 10	115	Not seen. Under *f*	Under 10·3	$<10·3$	Neb. 80 *M* as usual. Hazy.
1881. Mar. 29	14 55	115	Not seen ...	Under 13·5	$<13·5$	*h* and *k* seen. Neb. 80 *M* as usual.
May 8	12 50	115	$h-0-2$ ...	12·3 12·1	12·2	Neb. 80 *M* as usual.

S Scorpii—continued.

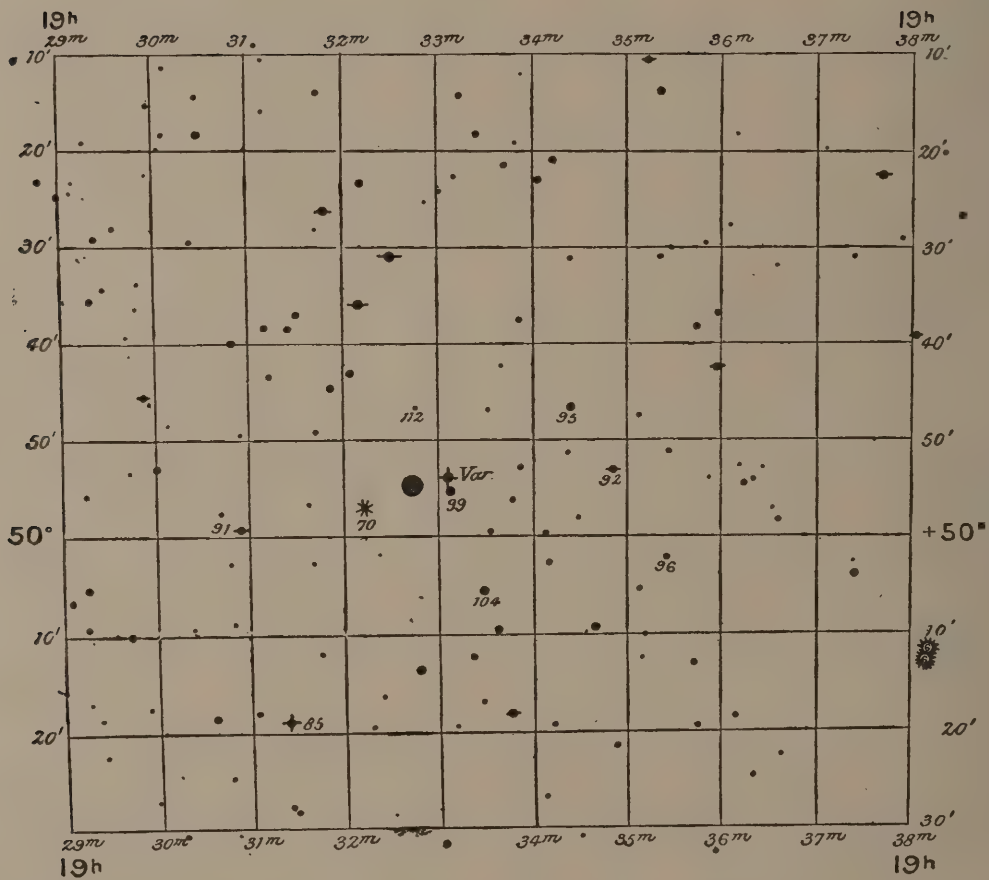
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881. May 20	h m 10 0	115	$f+10$; $g+3$; $h-10$	11·3 11·3 11·3	11·3	Well seen, but sky a little hazy. Neb. 80 *M* as usual.
30	10 0	70 115	$f+4$; $g-3$...	10·7 10·7	10·7	Neb. 80 *M* as usual. *R* not seen.
June 23	11 0	70	$=g$? $=g+$?	11·0? 11·2?	11·1?	Neb. 80 *M* as usual. *R* not seen.
July 4	10 15	70 115	$g+2+3$ ...	11·2 11·3	11·25	Neb. 80 *M* as usual. *R* not seen.
Aug. 10	9 0	70 115	Not seen. Under *f*	Under 10·3	< 10 3	Neb. as usual. *f* well in view.
1882. May 11	11 30	70 115	$=f$	10·3	10·3	Not so bright as *R*.
15	10 45	115	$e+4$; $f-2$...	10·1 10·1	10·1	*S* barely so bright as *R*.
18	11 35	70	$\frac{1}{2}(e+f)$ ...	10·0	10·0	*R* and *S* equal. Neb. 80 *M* as usual.
20	10 35	115	$e+2$; $f-4$...	9·9 9·9	9·9	Neb. 80 *M* as usual. Clear, but definition very bad, with east wind.
June 7	11 0	70	$d+2$; $e-1$...	9 6 9 6	9·6	Neb. as usual. A difficult obs. in clear intervals between clouds. *R* not seen, or qu. once glimpsed? *f* brighter than 10·3?
12	10 0	115	$=f$; $e+6$; $d+9$	10·3 10·3 10·3	10·3	Neb. 80 *M* as usual.
15	10 15	115	$f+3$; $g-4$...	10·6 10·6	10·6	Obs. rather doubtful. Hazy. Full aperture and with 4-inch aperture. Neb. 80 *M* as usual. *R* not seen.
July 24	9 45	115	Not seen ...	Under 11½	< 11½	*g* seen. *h* not seen. Neb. 80 *M* as usual. *R* not seen. Sky not clear, and Moon rather near.
Aug. 7	9 50	70	Not seen ...	Under 11	< 11	Neb. 80 *M* as usual.
1883 May 15	10 20	115	$f+4$; $g-3$...	10·7 10·7	10·7	A bright 11 mag. Neb. 80 *M* as usual. *R* not seen.
31	10 45	110	$f+10$; $h-10$; $g+3$	11·3 11·3 11·3	11·3	11¼ 11½ mag. Obs. a little difficult. *R* not seen. Less than 13. Neb. 80 *M* as usual.
June 1	10 50	115	$f+10$; $g+3$; $h-10$	11·3 11·3 11·3	11·3	Neb. 80 *M* as usual. *R* glimpsed. 13 13½ mag.?
15	10 45	115	Not seen ...	...	< 12·3?	*h* not seen. Neb. 80 *M* as usual.
25	10 57	115	Not seen ...	...	...	
28	10 30	110	Not seen ...	...	...	
30	10 50	70	Not seen ...	...	...	
Aug. 21	8 45	115	Not seen ...	...	...	*g* seen. Neb. 80 *M* as usual.
1884. June 30	10 23	70 115 110	Not seen ...	...	...	Neither *R* nor *S* seen. *f* and *g* seen; *h* not seen. *f* hardly so bright as 10·3?? Neb. 80 *M* as usual.
1885. Feb. 21	16 40	115	Not seen ...	Under 12?	< 12?	Neither seen. Under 12? *g* well seen. *h* glimpsed. Neb. 80 *M* as usual.
May 11	11 15	110 70	$f+4$; $g-3$...	10·7 10·7	10·7	Neb. 80 *M* as usual. Rather hazy. Obs. a little doubtful.
15	10 45	70 110	$=g$? ...	11·0?	11·0?	Neb. 80 *M* as usual.

S Scorpii—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885. June 1	h m 10 50	110	Not seen ...	Under 11	< 11	*g* seen. *h* not seen. Hazy. Neb. 80 *M* as usual.
17	10 25	115	Not seen ...	...	...	*R* seen. About 11 mag. Neb. 80 *M* as usual.
July 10	10 16	110	Not seen ...	...	...	Neb. 80 *M* as usual. Clear sky.
1886. June 1	10 20	115 200	Not seen ...	Under 12½ 13	< 12¾	*h* seen. *k* glimpsed. Neb. as usual. Glittering.
23	11 25	115	Not seen ...	...	...	*R* 12 mag. est. Neb. 80 *M* as usual. Rather bright centre?
30	10 16	115	Not seen ...	Under 12½	< 12½	Neb. 80 *M* as usual.
July 5	10 30	115	Not seen ...	Under 11·12?	< 11·12?	*h* not seen.
1887. May 20	10 25	70 115	Not seen ...	Under 10·3	< 10·3	*f* seen. Neb. 80 *M* as usual.
June 13	10 15	115	Not seen ...	Under 12·3	< 12·3	*h* glimpsed at times. Neb. 80 *M* as usual.
18	10 50	115	Not seen ...	Under 12½	< 12½	Neb. 80 *M* as usual. Glittering as a star mass.
30	10 30	115	Not seen ...	Under 11·12	< 11·12	*g* well seen. *h* not seen. Neb. 80 *M* as usual.
July 19	10 23	115	Not seen ...	Under 12·3	< 12·3	*h* seen fairly at times. Neb. 80 *M* as usual.
21	10 37	115	Not seen ...	Under 12·3	< 12·3	*h* well seen. Neb. 80 *M* as usual.
1888. May 1	11 0	110 115	... ...	13	13·0	*f*, *g*, *h* seen. *k*? Neb. 80 *M* as usual.
3	11 15	...	Not seen ...	Under 12¼?	< 12·25	Neb. 80 *M* as usual.
10	11 10	110 191	Not seen ...	Under 12	< 12·0	*h* glimpsed once or twice. Neb. 80 *M* as usual. Sparkles as cluster.
12	10 50	115	... ...	...	...	Not seen. Not very clear. Neb. 80 *M* as usual.
Aug. 8	9 10	115 191	... ...	...	...	Glimpsed at times? Neb. 80 *M* as usual.
13	9 0	115	... ...	...	...	*h* glimpsed. *S* glimpsed. Neb. 80 *M* as usual.
1889. June 3	10 45	115	Not seen ...	Under 12	< 12	*h* seen. Neb. 80 *M* as usual.
Aug. 7	8 55	115	*e*+2; *f*−4 ...	9·9 9·9	9·9	*R* and *S* both visible in hazy sky. Moon rather near. Neb. 80 *M* as usual.
1890 June 9	10 20	115	Not seen ...	Under 13	< 13	*h* and *k* seen. Neb. 80 *M* as usual.
Aug. 1	9 50	70 115	Not seen ...	Under 10	< 10	2.20 past meridian. Vision unsteady. Neb. 80 *M* as usual.
27	8 45	115	Not seen ...	...	...	*d* seen. Stars 3h past meridian and sky light. Neb. 80 *M* as usual.
1891. June 5	10 35	70 115	Not seen ...	Under 13	< 13	*h* glimpsed at times. Definition poor.
July 28	10 7	115	*f*+7; =*g* ...	11·0 11·0	11·0	2¼h past meridian. Neb. 80 *M* as usual.
Aug. 12	9 45	115	*e*+3; *d*+6 ±	10·0 10.0	10·0	3h past meridian. Obs. difficult.

Mr. Knott's Diagram, Epoch 1860 ?

R Cygni.



[The numbers assigned in the above diagram are ten times the assumed magnitudes of the stars.]

R Cygni.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 7045 *R Cygni*, R.A. for 1900·0=$19^h\ 34^m\ 8^s$, Decl.=+49° 58′·5.

Annual Variation=+1^s·61 and+0′·13.

R.A. for 1855·0=$19^h\ 32^m\ 56^s$, Decl.=+49° 52′·5.

Redness=6·0. Max. mag. 5·9—8·0. Min.<14.

$M-m=150^d$.

Maximum, 1854 Oct. 16=2398508^d·9 (Julian).

Period+425^d·7.

(From twenty-seven observations of max. and seven of min., including observations in 1817, 52–95.)

Discovered by POGSON, 1852. *θ Cygni* pr. 22^s, 0′·7 N.; 9^m foll. ·2^s, 1′·5 N.

R Cygni.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1864. Aug. 3·3	h m	60	11·7 est. ...		11·7 est.	
6·3			11·8 12·0 est.	11·8 12·0 est.	11·9 est.	
Sep. 23·3		60	13·2 est. ...		13·2 est.	
27·3		102	13·6 est. ...		13·6 est.	
29·3			13·6 est. ...		13·6	
Oct. 3·3		60	Below 13·5 not seen		< 13·5	
Nov. 3·3		102	13·7 est. ...		13·7 est.	
26·3		60	Not seen < 13·5		< 13·5	
1865. Jan. 20·3		60	99 + 1 ; 104 − 4	10·0 10·0	10·0	
21·3			99 + 1 ...	10·0 10·0		
28·3			95 + 3 ; 99 − 1	9·8 9·8	9·8	
Feb. 10·25				9·0 9·1	9·05	Ruddy. *z* not quite equal ✱ to South.
17·3		60	91 − 2 (?) ...	8·9	8·9	11^h past meridian.
24·3			85 − 1 − 2 ...	8·4 8·3	8·35	
28·4		60			8·4 ?	10$\frac{1}{2}^h$ from meridian, cloudy.
Mar. 2·5		60	85 − 2 ...	8·3	8·3	85 = 8^m·3 ? *R* ruddy.
Apr. 8·3			70 + 1 + 2 ...	7·1 7·2	7·15	(Phot. 7·3). Qu. 70 > 7·0 ?
21·3		60	70 + 3 ...	7·3	7·3	Fine ruddy colour.
24·35		60	70 + 2 + 3 ...	7·2 7·3	7·25	Ruddy.
May 2·4		60	70 + 6 ; 83 − 7	7·6 7·6	7·6	Fine ruddy.
15·5		60	83 − 3 ...	8·0	8·0	Fine red.
22·5		102	83 − 3 ...	8·0	8·0	Fine red.
24·5			83 − 3 ...	8·0	8·0	
31·4		60	8·3	8·3	8·3	Fine red.
June 6·5		102 ?	83 + 3 ; 91 + 5	8·6 8·6	8·6	Fine ruddy.
19·5			91 − 1 ; 99 − 8	9·0 9·1	9·05	Red.
27·5		60	= 91 ; 95 + 3 ; 99 − 7 − 8	9·1 9·2 9·2 9·1	9·15	Red.
July 11·4		60	= 95 ; 99 − 3	9·5 9·6	9·55	Ruddy.
19·5		60	= 95 ; 99 − 3 ; 96 − 1	9·5 9·6 9·5	9·5	Ruddy.
26·4		60	= 99 ; 99 − 1	9·9 9·8	9·85	Red.
Aug. 9·4			99 + 1 ; 104 − 3	10·0 10·1	10·05	Red.
14·4		60	99 + 6 ; 104 + 1	10·5 10·5	10·5	Hazy.
24·5			99 + 8 ; 104 + 3 ; 112 − 2	10·7 10·7 11·0	10·8	
Sept. 7·4			= 112 ...	11·2	11·2	
Oct. 20·3			13·5 est. ...		13·5 est.	
Nov. 3·4		70 173	13·7 est. ...		13·7 ?	A glimpse-object in a moon-lit sky.

R Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865.	h m					
Nov. 13·3		191	13·8 14·0 est		13·9 est.	A glimpse object.
29·3		191	Glimpsed ? ...		14·0 ?	Glimpsed suspiciously.
Dec. 14·3			Invisible ...	Below 13·8	< 13·8	
30·3		70	Not seen ...	Below 13·5 ?	< 13·5 ?	
1866.						
Jan. 12·3		70	Not seen ...	Below 13 ?	< 13 ?	
24·4		191	Not seen ...	Below 13·5	< 13·5	Fine night.
Feb. 7·5		191	Not seen ...	Below 13·5	< 13·5	$10\frac{1}{2}^h$ from meridian.
21·4		191	Glimpsed ? ...	13·7 14 ? ?	13·85 ? ?	
Mar. 12·4		70 ?	Glimpsed ? ...	13 13·3 ? ?	13·15 ? ?	Cloud and haze.
16·4		70 ?		13 5 13·7 est.	13·6 est.	
Apr. 4·4		191		13 ±	13 ±	Steadily seen. Among clouds.
13·4		70		12·5 est.	12·5 est.	Well seen. Clear.
17·5		70		11·7 ± est.	11·7 ± est	
25·3		70	99 + 2 ; 104 − 3	10·1 10·1	10·1	
May 4·3			= 91 ; 95 − 3 − 4	9·1 9·2 9 1	9·1	
16·4		70	83 + 4 ; 91 − 4	8·7 8·7	8·7	Decidedly ruddy.
19·5		70	91 − 7 ; 83 + 1	8·4 8 4	8·4	
23·5		70	= 83	8·3	8·3	Decidedly ruddy.
June 7·5		70		8·3 8·4	8·35	Decidedly ruddy.
14·4		60		8·4 8·5	8·45	Fine ruddy orange ?
22·4		70	83 + 7 ; 99 − 9	9·0 9·0	9·0	Past maximum.
July 9·4		70	83 + 3 ; 91 − 5	8·6 8·6	8 6	Red.
14·4		70	83 + 1 ; 91 − 7	8·4 8·4	8·4	Ruddy.
20·4		70	83 + 4 ; 91 − 4	8·7 8·7	8·7	Decidedly red.
Aug. 3·5		70	83 + 8 ; 99 − 8	9·1 9·1	9·1	Decidedly red.
9·5		70	91 + 6 ; 99 − 2	9·7 9·7	9·7	Fine red. Clouds coming up.
16·4		70	99 − 5 ; 95 − 1 ; 91 + 3	9·4 9·4 9·4	9·4	Decidedly ruddy. Brighter than it was on the 9th.
31·5		70	99 − 2 ...	9·7	9·7	Ruddy orange.
Sept. 14·3		60	= 99... ...	9·9	9·9	Ruddy.
Oct. 8·3		70	99 + 2 ...	10·1	10·1	Certainly fine red.
22·4		70		11·7 est.	11·7 est.	
Nov. 3·3		70		11·7 est.	11·7 est.	Among clouds.
13·3		70		11·5 ± est.	11·5	
27·3		70		13·0 est.	13·0 est.	
Dec. 7·3		70		12·5 13·0 est.	12·75 est.	
19·3		70 89		13·0 est.	13·0 est.	
1867.						
Mar. 2	12 ±		Not seen ...	Below 13	< 13	
May 21	12 ±	70		12·5 ±	12·5 ±	

R Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
June 4	11 30	70		11·5 ±	11·5 ±	Rather less than 112.
26	12 ±	70	99 − 3; −4?	9·6 9·5	9·5	9·5 est.
July 9	10 50	70	= 83; 91 − 7	8 3 8·4	8·35	Orange ruddy. 4-in. aperture.
31	10 +	70	< 70 > 83 ...	7·6 7·7 est.	7·65	Ruddy. 5-in. aperture.
Aug. 9	11 20	60	70 + 3; 83 − 10	7·3 7·3	7·3	Fine red. 5-in. aperture.
21	13 40	70	70 + 3 + 4; 83 − 10 − 9	7·3 7·4 7·3 7·4	7·35	Fine red. Less than 70 (So Mrs. Knott).
Sept. 10	11 20	70	70 + 3; 89 − 6* (So with 5 in. aperture)	7·3 7·3	7·3	Fine red. Very difficult to observe in consequence of colour. In the 2-in. finder it appears much less.
Oct. 5	8 20	70	83 − 3?	8·0?	8·0?	Fine clear pale red. 8 ± est.
19	8 45	70	83 + 5; 91 − 3	8·8 8·8	8·8	Fine clear ruby.
Nov. 23	8 ±	70	95 + 2; 99 − 2	9·7 9·7	9·7	Coppery red.
Dec. 2	7 ±	70	99 − 1; 99 − 2; 91 + 6	9·8 9·7 9·7	9 7	Coppery red. Bad definition.
26	7 30	70 60	112 − 1 − 2	11·1 11·0	11·05	11·0 ± est. Dull red.
1868.						
Feb. 21	12 0	89	Not seen ...	Below 11·5	< 11·5	10h from meridian.
Apr. 2	9 0	70	Not seen ...	Below 12	< 12	$9\frac{3}{4}$h from meridian and moonlight.
May 14	11 45	70 89	Not seen ...	Below 13·5	< 13·5	
Aug. 3	11 20	89		13·3 est.	13·3 est.	Close to meridian.
Sept. 5	10 35	70	91 + 3; 95 − 1; 99 − 5	9·4 9·4 9·4	9·4	Clear red.
30	8 0	70	70 + 10; 83 − 3	8·0 8·0	8·0	Clear pale red.
Nov. 2	10 30	60 70	70 + 8; 83 − 5	7·8 7·8	7 8	Coppery red. Obsn. rather doubtful.
Dec. 19	8 5	70	91 − 2; 95 − 6; 83 + 6	8·9 8·9 8·9	8·9	Fine clear copper colour.
23	7 40	70	91 − 2; 83 + 6	8 9 8·9	8·9	Coppery red.
1869.						
Jan. 5	7 55	70	91 + 3; 95 − 1; 99 − 5	9·4 9·4 9·4	9 4	Clear ruddy orange.
Feb. 2	7 30	89	= 99.·. ...	9·9	9·9	10 ± est. Clear red.
18	7 0	89		$10\frac{1}{2}$ est.	10·5 est.	Rather low.
June 15	12 5	191	Glimpsed ...	14 mag.	14 ±	Clear sky.
July 10	11 45	191	Not seen ...	Under 13·5	< 13·5	Inconvenient for observation.
Aug. 6	11 40	89	Not seen ...	Under 13·5	< 13·5	Clear. Good observation.
26	10 45	191		13·7 est.	13·7 est.	Clearly seen.
Sep. 21	8 50	70	99 + 5; = 104	10·4 10·4	10·4	Clear red.
Oct. 11	8 20	70	91 + 5; 99 − 3	9·6 9·6	9·6	Ruddy.
26	7 35	70	83 + 2; 99 − 14	8·5 8·5	8·5	Ruddy red. 8·5 est.
Nov. 11	6 45	70	= 70; 70 + 1 + 2; 83 − 12	7·0 7·1 7·2 7·1	7·1	Clear coppery red.

* [So in MS.; it is not easy to see what the mistake is; the original record has thus been left.—Ed.]

R Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Nov. 20	h m 7 20	70	70 + 2; 83 − 11	7·2 7·2	7·2	Clear red with slight orange cast. At times I am inclined to think *R* fully equal to 70.
30	7 50	70	= 70... ...	7·0	7·0	Fine clear red with slight copper cast.
Dec. 24	6 50	70	70 + 2 + 3? ...	7·2 7·3?	7·25?	Coppery red. Very nearly equal to 70. Not quite so bright.
1870. Jan. 5	7 55	70	70 + 5; 83 − 8	7·5 7·5	7·5	Clear red. Not easy to observe from its colour.
10	7 0	70	70 + 6; 83 − 7	7·6 7·6	7·6	Coppery red.
June 6	11 55	70		$12\frac{1}{2}$ 13 est.	12·75 ± est	Well seen.
Oct. 15	8 50	191	Glimpsed ...	14	14·0 est	Fine definition and clear.
1871. Jan. 12	7 0	70	91 + 2; 99 − 6	9·3 9·3	9·3	Clear orange red.

Mr. Knott's Diagram, Epoch 1865?

S Cygni.

Magnitudes of comparison stars :—

$a=7{\cdot}8$?	$e=9{\cdot}5$	$k=11{\cdot}7$
$b=8{\cdot}9$	$f=9{\cdot}8$	$l=12{\cdot}6$
$c=9{\cdot}0$	$g=10{\cdot}4$	$m=13{\cdot}1$
$d=9{\cdot}4$	$h=11{\cdot}2$	

S Cygni.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astr. Journal*, No. 379).

No. 7,220, *S Cygni*, R.A. for 1900·0=$20^h\ 3^m\ 24^s$, Decl. $=+57°\ 41'·9$.

Annual variations $=+1^s·26$ and $+0'·17$.

R.A. for 1855·0=$20^h\ 2^m\ 28^s$, Decl.= $+57°\ 34'·2$.

Redness=5·1. Max. mag.=8·8–11·3. Min.$<$14·5.

M$-m$=150^d.

Maximum, 1865 June 29=2402417^d (Julian).

Formula representing Period$+322·8$E$+15$ sin (12°E$+$66°).

(From thirty-two observations of max. and 2 of min., including observations in 1841 and 1860–1895.)

Discovered at Bonn, 1860. Secondary phases near max. $8^m·9$ foll. 1^s, $0'·8$ N.

S Cygni.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863. Sept. 10		60	10·3 est. ...		10·3	
18		60	$e+3$; $g-4$ ...	9·8 10·0	9·9	10·0 est.
23		60	$e-1$... ...	9·4	9·4	Fair obsn.
25		60	$=d$; $=e$ ...	9·4 9·5	9·45	
28		102	$=d$; $c+3+4$	9·4 9·3 9·4	9·4	Fine night.
Oct. 1			$b+5$; $=d$ ...	9·4 9·4	9·4	
6			$e+1$?	9·6	9·6	
13			$e+2$... ...	9·7	9·7	Tolerably fine.
23			$e+3$... ...	9·8	9·8	
Nov. 9·3		60	$=g$	10·4	10·4	Past maximum.
11		60	$=g$	10·4	10·4	
28		60	$=k$	11·7	11·7	
30			12 mag. est....		12·0	
1864. Jan. 5		191			14??	I believe that I glimpsed it once or twice.
Aug. 2			$e+2$; $f-1$ ...	9·7 9·7	9·7	
6·3			$e+2$; $f-2$ ...	9·7 9·6	9·65	
12·3			$e+1$; $f-2$ ...	9·6 9·6	9·6	
Sept. 22·3		60	$f+2$; $g-3$ ...	10·0 10·1	10·05	Fair, not very clear.
23·3		60	$f+3$; $g-2$ ...	10·1 10·2	10·15	
27·3		60	$f+4$; $g-1-2$	10·2 10·3 10·2	10·2	
Nov. 4·3		102	12·8? est. ...		12·8?	
1865. Feb. 17·3		60	Not seen. Below 13·1		< 13·1	
24·3			Invisible. Below 13·7		< 13·7	
Apr. 22·3			Invisible. Below 13·7		< 13·7	
May 2·4		173	Some tenths less than m	13·7	13·7	A glimpse object.
15·5		102	$m+1$ ...	13·2	13·2	13·3 est.
22·5		102	$=m$... ...	13·1	13·1	
31·4		60	$g+4+5$; $k-8$	10·8 10·9 10·9	10·9	
June 19·5			$e+4$; $=f$; $g-5$	9·9 9·8 9·9	9·9	
27·5			$e+3$; $g-4-5$	9·8 10·0 9·9	9·9	
July 11·4		60	$e+1$; $f-1$ ...	9·6 9·7	9·65	Fine moonlight.
19·5		60	$e+1+2$; $f-1-2$	9·6 9·7 9·7 9·6	9·65	
26·4		60	$c+6+7$; $e+2+3$; $f-1$	9·6 9·7 9·7 9·8 9·7	9·7	
28·5		60	$e+1+2$; $f-1-2$; $c+7$	9·6 9·7 9·7 9·6 9·7	9·7	

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865. Aug. 9·4		60	$e+6$; $f+2$; $g-2$	10·1 10·0 10·2	10·1	
11·5			$e+6$; $f+2$; $g-3$	10·1 10·0 10·1	10·1	
14·4		60 173	$g-1$... ...	10·3	10·3	
18·4		60	$g-0-1$ ...	10·4 10·3	10·35	
24·5			$g+6$; $k-5$...	11·0 11·2	11·1	
30·4			$g+5$; $k-6$...	10·9 11·1	11·0	
Sept. 7·4			$=k$	11·7	11·7	Very much less than g. At *least* one mag. less.
18·3		60	$l+3$; $m-3$	12·9 12·8	12·85	
Oct. 3·4		191	$m+5$ ...	13·6	13·6	A glimpse object.
20·3					14 ±	Painfully glimpsed.
Nov. 3·4		191	Invisible ...	Below 13·5	< 13·5	
13·3		191	Invisible ...	Below 13·5	< 13·5	
29·3		191	Invisible ...	Below 13·7	< 13·7	
1866. Jan. 8·4		191	Invisible ...	Below 13·5	< 13·5	
Feb. 7·5		191	Not seen ...	Below 13·5	< 13·5	m visible.
21·4		191	$m+2+3$ ...	13·3 13.4	13·35	
Mar. 10·3		191	$=k$? $k-1-2$?	11·7 11·6 11·5	11·6	Hazy. 11·7 est.
16·4		70	$h+1+2$; $k-4$	11·3 11·4 11·3	11·3	10ʰ from meridian.
Apr. 4·4		70 191	$g+1+2$; $k-12$	10·5 10·6 10·5	10·5	
11·3		70	less than g?...		< 10·4 ?	Observation interrupted by clouds.
13·5		70	$=g$	10·4	10·4	
17·4		70	$g-0-1$ ...	10·4 10·3	10·35	
20·3		70	$f+4$; $g-1-2$	10·2 10·3 10·2	10·2	
25·3		70	$f-0-1$ ...	9·8 9·7	9·75	
May 4·4			$e+3$; $g-6$...	9·8 9·8	9·8	Qu. is f variable? 10·1 est.?
16·4		70	$c+5$; $=e$ ...	9·5 9·5	9·5	Ruddy?
19·5		70	$c+4$; $=d$; $e-1$	9·4 9·4 9·4	9·4	$f=$ 10·0 10·1 est.
23·4		89	$c+4$; $=d$ ...	9·4 9·4	9·4	Ruddy.
28·4		70	$c+3$; $e-2$ ...	9·3 9·3	9·3	
June 7·5		70 89	$c+4$; $e-0-1$	9·4 9·5 9·4	9·4	
14·4			$c+4+5$; $=e$	9·4 9·5 9·5	9·5	Bluish?
22·4		70	$c+7+8$; $e+3+4$; $=f$	9·7 9·8 9·8 9·9 9·8	9·8	$f=9·8$.
25·4		70 89	$e+6+7$; $f+3$; $g-3$	10·1 10·2 10·1 10·1	10·1	Past maximum.
July 9·4		70	$g-1$... ...	10·3	10·3	
14·4		70	$g+1$... ...	10·5	10·5	
19·4		89	$g+6$; $h-3$...	11·0 10·9	10·95	Clouds troublesome.
20·4		89	$h-0-1$ ...	11·2 11·1	11·15	

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866. Aug. 3·5		191	$k+4+5$ ...	12·1 12·2	12·15	12·0 12·5 est.
9·4		191	$m-1-2$ ...	13·0 12·9	12·95	12·9 13·0 est.
Sept. 14·3		191	A glimpse object?	14·0 14·3?	14·15?	Sky clear.
Oct. 8·3		70 191 258	Not seen ...	Below 13·7 or 14·0	< 13·9	Attentive gazing. Clear.
Nov. 13·3		173 191	Not seen ...	Below 14	< 14	Sky clear.
27·3		191	Not seen ...	Below 13·5	< 13·5	Hazy.
Dec. 7·3		191	Not seen ...	Below 13·5	< 13·5	
19·3		89 191	Not seen ...	Below 13·2	< 13·2	
29·5		70 89	Not seen ...	Below 10½ or 11	< 10½ or 11	Among trees. A stiff breeze from the west. Sky clear, but definition poor. Air much disturbed.
1867. Jan. 4·3		70 89	Not seen ...	Below 11·5 or 12	< 11·5 or 12	10½ hrs. past meridian and among trees. Certainly below 11·5 or 12 mag.
8·3		191	A faint glimpse object	14·0 ±	14·0 ±	
11·25		191	A feeble glimpse object	13·7 est.	13·7 est.	6ʰ past merid. Determined mags. of Comp. stars as follows. Several stars var.? *b*8·9; *c*9·0 est.; *d*9·6 est.; *e*9·5; *f*10·0; *g*10·7; *h*11·1; *k*11·95; *l*12·8; *m*13·1; *b* more ruddy and slightly > *c*?
Feb. 4	h m 8 20	70	Some tenths less than *m*	13·7 est.	13·7 est.	
14	7 –	89 191	$k+6$; $=l$; $m-8$	12·3 12·6 12·3	12·4	Moonlight. Bad definition. Obs. doubtful. *b* ruddy and brighter than *c*.
20	6 30	70 89	$h+5$; $k-1-2$	11·7 11·6 11·5	11·6	Gauged $h=11·2$ 11·3; $k=12·0$; $l=12·7$. But stars far from meridian, and haze coming up.
23	7 +	89 191	$h+4+5$; $k-2-3$	11·6 11·7 11·5 11·4	11·55	
Mar. 2		70 89	$h+2+3$? ...	11·4 11·5	11·45?	10½ʰ past meridian. Very bad definition.
Apr. 29	11 ±	70 89	$c+3$; $e-2$ ...	9·3 9·3	9·3	Ruddy orange.
May 21	12 15	89	$e+3$; $g-6$ ...	9·8 9·8	9·8	Rather ruddy.
June 1	14 10	89	$g+3$; $h-5$ ...	10·7 10·7	10·7	Sky clear and definition good.
26	12 ±	89	$m+3$? ...	13·4 ±	13·4 ±	13·5 ± est. Glimpsed.
July 9	11 0	89	Glimpsed ...	13·5 ± est.	13·5 ±	Clear.
Oct. 19	9 ±	191	Not seen ...	Below 13·7	< 13·7	Clear sky. *m* bright.
Nov. 2	9 ±	191	Not seen ...	Below 13·5	< 13·5	
23	8 30 ±	89 191	Not seen ...	Below 13·3	< 13·3	*m* seen.
Dec. 2	7 30	191	Not seen ...	Below 13	< 13	Drifting snow clouds from N.*b*.W.
12	7 5	191	Not seen ...	Below 13	< 13	
26	7 40	191	Seen by glimpses	13·7 ±	13·75 ±	Some 6 or 7 tenths less than *m*.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1868.	h m					
Feb. 11	12 0	89 191	$e+5$; $g-4$ ...	10·0 10·0	10·0	$10\frac{1}{2}^{h}$ from meridian.
Apr. 2	8 50	191	$g+1$? ...	10·3?	10·3?	$10\frac{1}{2}^{h}$ fr. meridian and vision not very clear.
May 14	11 55	191	A glimpse object	13·8 ±	13·8 ±	Clear and still.
Aug. 3	11 25	191	Not seen ...	Below 13·7	< 13·7	*m* well seen.
Sept. 5	10 45 ±	191	Not seen ...	Under 13·5	< 13·5	Clear.
30	8 0 +	191	Not seen ...	Under 13·5	< 13·5	*m* well seen.
Nov. 2	9 0	191	$m+0+2$ ...	13·1 13·3	13·2	Clear. Good observation.
5	8 45	191	$l+3$; $m-2$...	12·9 12·9	12·9	Well seen.
24	11 30	191		12·0 ± est.	12·0 ±	Moonlight and haze. Qu. Is there a var. star, *h* or? See chart. A star which I take to be *h* is of abt. 11 mag. Clouds came up.
Dec. 17	8 15	89	$f+4$ $g-2$...	10·2 10·2	10·2	Careful comparison.
23	7 35	70 89 191	$f+2$; $g-4$...	10·0 10·0	10·0	Clear and still moonlight.
30	10 35	89	$e+2$; $g-7$...	9·7 9·7	9·7	*f* seems fainter than 9·8, more like 10·0. *S* ruddy? Decidedly so, I think. Bright moonlight.
1869						
Jan. 5	7 45	70 89	$c+3$; $d-0-1$	9·3 9·4 9·3	9·3	Ruddy decidedly. $c \doteq b+1$; d not $> e$.
19	12 55	70	$c+3$; $e-2$?	9·3 9·3?	9·3?	$11\frac{1}{4}$ hrs. from meridian and obs. rather doubtful.
Feb. 2	7 20	89	$c+1+2$; $d-2$	9·1 9·2 9·2	9·2	Sky clear and stars steady. *S* ruddy orange.
4	8 10	191	$c+5$; $=e$ ...	9·5 9·5	9·5	Observation fair. *S* ruddy orange.
18	6 50	89 191	$d+6$; $f+2$; $g-4$	10·0 10·0 10·0	10·0	Ruddy?
27	7 20	191	$f+1$; $g-5$...	9·9 9·9	9·9	$9\frac{3}{4}$ hrs. past meridian. Obs. interrupted by passing clouds. Fair obs.
Apr. 4	9 0	70	Not seen ...	Under 11·2	< 11·2	*h* seen. *k* not seen. Hazy, and star 10 hrs. fr. merid.
June 15	12 10	191	Not seen ...	Under $13\frac{3}{4}$ 14	< 13·75, 14·0	*m* well seen.
July 10	11 50	191	Not seen ...	Under 13·2	< 13·2	*m* glimpsed.
Aug. 6	11 50	191	Not seen ...	Under 13·3	< 13·3	*m* seen.
26	10 50	191	Not seen ...	Under 13·5	< 13·5	*m* seen.
Sept. 21	9 53	258	Feebly glimpsed	$13\frac{3}{4}$ 14	13·9	Obs. not quite certain?
Oct. 9	7 50	70	Not seen ...	Under $11\frac{1}{2}$	< $11\frac{1}{2}$	Doubtful observation.
11	8 27	191		13·7 est.	13·7 est.	Clearly seen. Careful comparison.
26	7 43	191	$k+3$; $l-6$...	12·0 12·0	12·0	Vision not always clear. 12 ± est.
Nov. 4	10 35	173		11·4 est.	11·4 est.	
6	8 35	191	$h+2$; $k-3$...	11·4 11·4	11·4	Clear. Well seen.
11	6 53	191	$g+2$; $h-6$...	10·6 10·6	10·6	Good observation.
20	7 30	89	$e+5$; $g-4$...	10·0 10·0	10·0	10·0 est. Fair observation.
28	8 50	70 173	$e+3$; $f=$; $g-6$	9·8 9·8 9·8	9·8	Ruddy?

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Nov. 30	h m 8 0	89	$e+2$; $f-1$ ...	9·7 9·7	9·7	Decidedly ruddy est.
Dec. 24	6 40	89 191	$e+3$; $=f$; $g-6$	9·8 9·8 9·8	9·8	Well observed. Lilac tint?
1870. Jan. 5	7 45	191	$f+2$; $g-4$...	10·0 10·0	10·0	10 mag. est. Slightly ruddy?
10	6 55	191	$f+6$; $=g$	10·4 10·4	10·4	Well seen. Clear.
June 6	12 0	89	Not seen ...	Under 13	< 13	Clear.
Oct. 15	8 45	70	$=c$	9·0	9·0	An exact comparison. *b* rather brighter and with a ruddy shade? *S* greyish white. Beautiful definition.
24	10 50	70 89	$b+0·5$; $c-0·5$	8·95 8·95	8·95	Perhaps slightly brighter than *c*. Ruddy?
26	7 40	70 191	$=c$	9·0	9·0	*S* decidedly ruddy; in contrast with *c*, which is greyish white. *b* is ruddy, and I think rather more than 0·1 > *c*. *S* is perhaps slightly > *c*.
1871. Jan. 12	6 54	191	Feebly glimpsed	13·5 14 est.	13·5 14*e* 13·75	Clear.
May 17	12 15	89	Not seen ...	Under 13·5	< 13·5	*m* well seen.
June 28	10 55	70 115	Not seen ...	Under 13·5	< 13·5	*m* well seen.
July 22	11 25	115	Not seen ...	Under 12	< 12	
Aug. 15	11 50	115		12·0 est.	12·0	*k* and *l* seen.
31	11 7	115	$g-0-1$ ...	10·4 10·3	10·35	Well seen.
Sept. 9	10 35	115	$f+3$; $g-3$...	10·1 10·1	10·1	Clear.
20	10 30	115	$f+3+2$; $g-3-4$	10·1 10·0 10·1 10·0	10·05	Careful estimate. I doubt whether *S* is much if at all brighter than on Sept. 9.
Oct. 9	11 15	70 115 191	$g+1$; $f+7$ ...	10·5 10·5	10·5	I have much difficulty in satisfying myself as to the mag. of *S*. I certainly have not (I think) rated it *too low*. Has the star passed its max.? Very clear. I should estimate it $10\frac{1}{2}$ or $10\frac{3}{4}$.
12	11 30	151 191	$g+8$; $=h$; $k-5$	11·2 11·2 11·2	11·2	Clear. Estimated $11\frac{1}{4}$.
14	8 5±	115	$=h$? ...	11·2	11·2	Clear.
23	9 5	115	$=k$	11·7	11·7	Clear.
Nov. 18	8 25	191	Feebly glimpsed	13·7±	13·7	Some tenths less than *m*.
29	7 25	191	Not seen ...	Under 13	< 13	Clear.
1872. Jan. 6	7 35	191	Not seen ...	Under 13·5	< 13·5	Under 14? Clear.
Mar. 5	11 20	70 191	Not seen ...	Under 13·1	< 13·1	Less than *m*. *m* seen, as also the small star n p. *c*.
Apr. 13	11 0	156	Glimpsed ...	13·7?	13·7?	
May 15	11 20	191	$m+4$ ...	13·5	13·5	
21	11 15	115 258	$=k$?... ...	11·7?	11·7?	A bright 12 mag. Obs. a little doubtful.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1872.	h m					
June 13	11 25	115	$g+6$; $h-2$ ...	11·0 11·0	11·0	Clear. Well seen.
29	11 45	115	$e+9$; $=g$ ...	10·4 10·4	10·4	Clear.
July 9	11 20	70	$e+1$; $f-2$ ...	9·6 9·6	9·6	Good obs. Clear.
20	11 45	70	$c+1$; $d-3$ ...	9·1 9·1	9·1	Slightly ruddy.
Aug. 27	11 40	115	$c+7$; $e+2$; $f-1$	9·7 9·7 9·7	9·7	Slightly ruddy?
31	10 30	70 115	$e+3$; $=f$; $f-1$	9·8 9·8 9·7	9·8	Clear, but obs. a little doubtful.
Sept. 5	8 55	115	$=f$	9·8	9·8	A bright 10 mag.
16	11 20	70	$f+3$; $g-3$ ...	10·1 10·1	10·1	Obs. among clouds. Obs. a little doubtful. *S* 10 mag. est.
19	11 0	191	$g+1$; $h-7$ ...	10·5 10·5	10·5	10½ est.
Oct. 7	10 45	115	$=k\pm$ ...	11·7	11·7	Obs. caught in clear interval between clouds. A little doubtful.
22	10 20	115		12½ 13	12·75	Glimpsed. Hazy.
1876. Nov. 16	9 20	191	$=l$?	12·6	12·6	A doubtful observation. *S* fairly seen at times.
20	7 45	191	$=l$?	12·6	12·6	Fairly seen at times. 12½ ± mag. est.
29	8 15	191	$h+3$; $k-2$...	11·5 11·5	11·5	Well seen. Moonlight.
Dec. 22	6 50	89	$f+2$; $g-4$ ...	10·0 10·0	10·0	A clear sky.
1877. Jan. 9	8 25	89	$=f$; $g-5$; $e+4$	9·8 9·9 9·9	9·9	Clear, but rather confused.
17	10 20	156 89	$=f$; $g-5$ ...	9·8 9·9	9·85	Obs. a little doubtful.
20	7 0	115	$f+3$; $g-3$ ...	10·1 10·1	10·1	The brightness of *c* makes obs. of *S* rather difficult.
24	7 40	191	$f+3$; $g-3$ ...	10·1 10·1	10·1	Moonlight and much haze. Obs. very difficult. *S* about 10 mag.?
25	8 20	115 191	$f+5$; $g-1$ ...	10·3 10·3	10·3	Clear sky.
30	7 35	115 191	$=g$	10·4	10·4	Clear sky.
Feb. 16	6 45	191	$h+2$; $k-3$...	11·4 11·4	11·4	Clear. Bad definition. 11¼ est.
20	7 50	115	Glimpsed abt $=k$?	11·7	11·7	High wind from N.N.W. Bad definition.
Mar. 22	11 0	115	Not seen ...	Under 13·5	< 13·5	*m* seen? *S* feebly glimpsed at times?
Apr. 26	11 55	191	Not seen ...	Under 13·5	< 13·5	*m* well seen.
May 15	11 30	115 191	Not seen ...	Under 13¼	< 13·25	*l* and *m* seen.
June 23	11 40	191	Not seen ...	Under 11½?	< 11½?	A doubtful obsn.
July 30	12 45	191	Not seen ...	Under 13	< 13	*l* and *m* seen.
Aug. 17	12 35	115		13½ 14 est.	13·75 est.	Well seen by fits.
Sept. 27	11 55	115	$f+5$; $g-1$ ...	10·3 10·3	10·3	A little difficult to observe from its nearness to *c*.
Oct. 2	11 20	115	$f+3$; $g-3$ ...	10·1 10·1	10·1	Pretty clear.
5	11 5	115	$f+2$; $g-4$ ...	10·0 10·0	10·0	Clear sky.
9	9 5	115	$f+2$; $c+10$; $g-4$	10·0 10·0 10·0	10·0	Abt. 10 mag. est.

S Cygni—continued.

Date of Observation.	G M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877. Oct. 15	h m 11 45	115 191	$c+7$; $e+2$; $f-1$	9.7 9.7 9.7	9.7	Certainly not less than *f*.
22	11 45	115 191	$c+5$; $=e$ ...	9.5 9.5	9.5	Slightly ruddy ? ? Moonlight.
27	10 25	60 70 115	$b+1$; $=c$; $d-4$	9.0 9.0 9.0	9.0	Slightly ruddy ?
Nov. 1	12 5	70	$=b$; $c-1$ ...	8.9 8.9	8.9	Slightly ruddy ?
8	9 30	115	$b+2$; $d-3$ ...	9.1 9.1	9.1	*c* brighter than *b* ? Clouds troublesome and obs. very doubtful if not quite worthless.
14	8 0	60 70 115	$b+1$; $=c$ ...	9.0 9.0	9.0	Slightly ruddy. $=c$, which is about $0.1 < b$. Certainly *c* is *not* to-night brighter than *b*. Clear sky. Defn. pretty fair.
17	8 25	70 115	$c+1$... ...	9.1	9.1	Slightly ruddy ? About as much less than *c* as *c* is than *b*. Haze and cloud about.
19	10 25	89	$c+1$; $d-3$...	9.1 9.1	9.1	Ruddy.
22	8 15	70	$c+2$... ...	9.2	9.2	Ruddy. Clear, but very high wind.
30	8 20	156 115	$e+2$; $f-1$...	9.7 9.7	9.7	Evidently past maximum. Clouds troublesome.
	8 25	70	$e+1.5$; $f-1.5$	9.65 9.65	9.65	Slightly ruddy ? $\frac{1}{2}(e+f)=S$.
Dec. 6	9 5	89 191	$c+8$; $=f$; $e+3$; $g-6$	9.8 9.8 9.8 9.8	9.8	Obs. difficult. Wind high. Clear, but very poor definition. Stars "*boiling*."
10	6 55	70	$f+2$; $g-4$; $c+10$	10.0 10.0 10.0	10.0	Clear. A good observation. I do not notice any ruddy tint in *S*.
12	8 53	115	$f+2$; $g-4$...	10.0 10.0	10.0	Clear. Good observation.
18	8 40	89	$f+4$; $g-2$...	10.2 10.2	10.2	Moonlight and haze troublesome. A doubtful observation.
24	8 43	70 115	$=g$	10.4	10.4	10.5 mag. est. Clear sky.
27	7 25	115	$g+6$; $h-2$; $k-7$	11.0 11.0 11.0	11.0	Abt. 11 mag. est. Clear and cold.
1878. Jan. 7	7 50	115 191	$k+3$; $l-6$ ...	12.0 12.0	12.0	Abt. 12 mag. estd. Obs. a little doubtful. *S* overpowered by brightness of its neighbour *c*.
Mar. 15	11 45	115 191	Not seen ...	Under 13.5 14	<13.75	*m* well seen.
May 11	11 45	115	Not seen ...	Under 13.1	<13.1	*m* well seen. Observed in clear intervals between clouds.
25	12 10	191	Not seen ...	Under $13\frac{1}{4}$	<13.25	*l* and *m* seen. Not perfectly clear.
31	10 50	191	Not seen ...	Under $13\frac{1}{4}$	<13.25	*m* seen.
June 6	12 37	115	Not seen ...	Under 13	<13	*l* and *m* seen.
12	11 35	191	Not seen ...	Under 13.5	<13.5	*l* and *m* seen.
25	12 15	115	Not seen ...	Under 13	<13	*m* seen. Inconvenient for observation.
July 19	10 45	115	Glimpsed ? ...	13.5	13.5	Rather doubtful.
Aug. 1	11 10	191		13.5 est.	13.5 est.	Less than *m* by a few tenths.
8	11 0	115	$=m$	13.1	13.1	Clear. Close to meridian.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1878. Oct. 12	h m 9 20	115	$c+8$; $e+3$; $=f$; $g-6$	9·8 9·8 9·8 9·8	9·8	Slightly ruddy. Full moon. Clear.
14	11 45	70	$c+9$; $e+4$; $f+1$; $g-5$	9·9 9·9 9·9 9·9	9·9	Clear. Defn. not good. Careful estimates.
17	9 0	191	$e+2+e$; $f-1$	9·7 9·8 9·7	9·7	Clear.
23	8 50	115 191	$f+1$; $g-5$...	9·9 9·9	9·9	Poor definition.
Nov. 1	8 30	115	$f+6$; $=g$ ...	10·4 10·4	10·4	$10\frac{1}{2}$ est. Clear sky.
7	8 50	115	$g+3$; $h-5$...	10·7 10·7	10·7	Clear. Bright moonlight.
16	7 30	191	$h+5$; $=k$ ...	11·7 11·7	11·7	A bright 12 mag. estimated.
1879. July 24	10 8	115	$e+5$; $g-3-4$	10·0 10·1 10·0	10·0	Slightly ruddy. Clear.
29	10 0	89 115	$e+5$; $g-3$...	10·0 10·1	10·05	Qu. f less than 9·8 mag.? $5\frac{1}{2}$ in. aperture.
Aug. 11	8 35	60	$c+3$; $d-1$; $e-2$	9·3 9·3 9·3	9·3	Slightly ruddy. For comparison with d and e, c hidden behind bar of eyepiece. The mags. of d, e, f seem to be about correctly assigned on chart.
25	10 55	89 60	$c+3$; $e-2$...	9·3 9·3	9·3	Slightly ruddy. With c behind bar S rather brighter than e.
30	10 50	60	$c+4$; $e-1$...	9·4 9·4	9·4	For comparison with e, c hidden by bar of eyepiece. Obs. among clouds. Obsn. rather doubtful.
Sept. 1	11 20	89	$c+4$; $=d$; $e-1$;	9·4 9·4 9·4	9·4	Ruddy. Clear. Fine. Bright moonlight.
Oct. 3	10 55	115	$g+3+4$; $h-5$	10·7 10·8 10·7	10·7	Clouds coming up. Fair observation.
6	8 25	191	$g+8$; $=h$; $k-5$	11·2 11·2 11·2	11·2	Clear sky.
11	8 0	191	$h+4$; $k-1$...	11·6 11·6	11·6	Clear sky.
15	10 20	191	$h+5$; $=k$ ...	11·7 11·7	11·7	Fairly clear. Bad definition.
1880. Jan. 2	8 10	191	Not seen ...	Under 13	< 13	l and m well seen.
Apr. 20	10 45	191	Not seen ...	Under 13·3	< 13·3	l and m well seen.
May 17	10 45	191	$h+2$; $k-3$...	11·4 11·4	11·4	Clear sky.
28	10 45	115	$g+8$; $=h$; $k-5$	11·2 11·2 11·2	11·2	Clear sky.
June 7	11 0	115	$g+4$; $h-4$...	10·8 10·8	10·8	Clear. Well seen.
25	11 5	115	$=g$; $h-8$ ...	10·4 10·4	10·4	Clear spaces among clouds.
Aug. 10	10 45	115 191	$k+3$... ...	12·0	12·0	Certainly less than k. Distinctly brighter than l.
Sept. 29	8 40	191	Not seen ...	Under $13\frac{1}{2}$	< 13·5	
Oct. 18	7 45	115	Not seen ...	Under 13·1	< 13·1	m seen.
1881. Apr. 4	9 5	115	$=h$?... ...	11·2	11·2	10^h from meridian. Well seen. Certainly a good deal less than g and greater than k.
26	10 25		$=e$; $f-2-3$	9·5 9·6 9·5	9·5	About 9·5 mag. est.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881. May 20	h m 11 5	115	$c+5$; $=e$ ...	9·5 9·5	9·5	5^h from meridian.
30	9 40	60	$e+1$; $f-2$; $c+6$	9·6 9·6 9·6	9·6	Comparison between *S* and *e* with *c* hidden by bar of eyepiece.
July 4	11 10	115	$=h$	11·2	11·2	
Aug. 6	9 0	191	Not seen ...	Under 13·1	< 13·1	*l* and *m* seen.
Sept. 30	8 47	115	Not seen ...	Under 13	< 13	Clear. *l* and *m* seen.
Dec. 5	9 0	191	Not seen ...	Under $12\frac{1}{2}$	< $12\frac{1}{2}$	Moonlight and haze. *k* well seen. *l* glimpsed.
29	7 22	115	Not seen ...	Under 12·6 13	< 12·8	*l* seen and *m*.
1882. Oct. 25	9 10	156	Not seen ...	Under 13	< 13	*l* and *m* seen.
Dec. 19	9 0	110	$h+1$; $k-4$...	11·3 11·3	11·3	Well seen.
1883 Feb. 6	6 28	70 110	$e+1$; $f-2$...	9·6 9·6	9·6	
13	9 5	70	$c+2$; $d-2$...	9·2 9·2	9·2	$10\frac{1}{2}^h$ past meridian.
22	7 55	110	$c+2+3$; $d-1$; $e-2$	9·2 9·3 9·3 9·3	9·3	(*b* 8·9, *c* 9·0, *d* 9·4, *e* 9·5).
24	6 53	110	$c+2$; $d-2$; $e-3$	9·2 9·2 9·2	9·2	Slightly ruddy?
Mar. 2	8 25	110	$c+3$; $d-1$; $e-2$	9·3 9·3 9·3	9·3	Ruddy?
14	9 3	110	$e+3$... ...	9·8	9·8	$12\frac{1}{2}^h$ past meridian. Hazy sky. A bright 10 mag.
22	7 54	70 115	$c+10$; $e+5$; $g-4$	10·0 10·0 10·0	10·0	About 10·0? *f* as bright as 9·8? More like 10·1.
1884. June 30	11 55	115 191	Not seen ...	Under $12\frac{1}{2}$	< 12·5	*h* and *k* seen.
July 17	11 0	191	Not seen ...	Under $12\frac{1}{2}$	< 12·5	*l* glimpsed.
Oct. 4	8 40	191	Glimpsed ...	13·5	13·5	*l* and *m* well seen. Moon half eclipsed.
13	8 40	191	Well seen at times	13·5	13·5	13·5 est. *l* and *m* well seen.
16	8 35	191	... ...	13·3 13·5	13·4	Well seen. Slightly brighter than on 13th?
22	11 15	191	$l+4$; $m-1$	13·0 13·0	13·0	Obs. a little doubtful. *c* ruddy = $b+1$.
24	9 0	115	$l+4$; $m-1$	13·0 13·0	13·0	
28	9 12	191	$k+3$; $l-6$...	12·0 12·0	12·0	Brightening up.
Nov. 7	8 50	115	$h+2$; $k-3$...	11·4 11·4	11·4	Increasing in brightness.
15	8 20	115	$g+3$; $k-10$	10·7 10·7	10·7	10·7 gauged.
19	8 20	115 191	$e+9$; $f+6$; $g-0-1$	10·4 10·4 10·4 10·3	10·4	Well observed.
22	8 10	115	$f+5$; $g-1$...	10·3 10·3	10·3	
28	8 24	115	$f+3$; $g-3$...	10·1 10·1	10·1	
Dec. 4	7 45	70 115 191	$f+2+3$; $g-3$	10·0 10·1 10·1	10·1	Clear sky. A gale subsiding. Still high wind. *S* no brighter than when last seen? At least a mag. less than *c*.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884.	h m					
Dec. 9	7 40	115 191	$f+5$; $g-1$ ...	10·3 10·3	10·3	Certainly past maximum?
15	8 13	115 191	$f+5$; $g-1$ ...	10·3 10·3	10·3	Careful obs. Not changed since obs. of Dec. 9?
17	8 22	115 191	$f+5$; $g-1$ ...	10·3 10·3	10·3	
1885						
Jan. 6	8 30	115	$g+2+3$; $h-6-5$	10·6 10·7 10·6 10·7	10·65	Obs. a little doubtful.
7	6 32	115	$g+3+4$ ...	10·7 10·8	10·75	Rather hazy sky.
20	8 27	115 191	$h+2$; $k-3$...	11·4 11·4	11·4	
Feb. 5	7 5	191	$l+3$; $m-2$...	12·9 12·9	12·9	Well seen. Clear, but high wind.
Oct. 3	10 10	...	$c+7$; $e+2$; $f-1$	9·7 9·7 9·7	9·7	$9\frac{3}{4}$ est. Slightly ruddy.
27	7 0	115	$c+5$; $=e$ ...	9·5 9·5	9·5	Ruddy.
Nov. 4	8 40	115	$e+3$; $g-6$; $=f$	9·8 9·8 9·8	9·8	
7	10 0	115	$e+3$; $=f$ ...	9·8 9·8	9·8	Orange tint.
16	8 5	115	$e+2$; $f-1$ ...	9·7 9·7	9·7	Ruddy.
1886.						
June 30	11 10	200	$m+6$ ...	13·7	13·7	Glimpsed at times. 13·7 ±.
July 15	11 3	115	Glimpsed; 13·5	13·5 ±	13·5 ±	
24	10 5	115	$m+2$ ...	13·3	13·3	Well seen. 13·3 est.
Aug. 10	9 0	115 200	$m+1$; $l+6$...	13·2 13·2	13·2	Sky clear. The star does not seem to have brightened up much since last observation.
Sept. 30	9 0	70 115	$e+3$; $f+0$; $g-6$	9·8 9·8 9·8	9·8	Ruddy.
Oct. 2	9 50	115	$e+2$; $f-1$...	9·7 9·7	9·7	Orange tint?
21	8 30	115	$f+3$; $g-3$...	10·1 10·1	10·1	
Dec. 2	8 30	191	$m+4$ ...	13·5	13·5	13·5 est.
1887.						
Apr. 14	10 25	115 191	Not seen ...	Under 13·5	$<13·5$	Clear.
30	10 55	191 115	Not seen ...	Under 13·5	$<13·5$	*m* well seen.
May 10	11 30	115 191 110	Not seen ...	Under 13	<13	*m* seen. Hazy sky.
20	10 55	191	Not seen ...	Under 13·5	$<13·5$	*m well* seen.
June 13	11 10	115	$m+3$ ...	13·4	13·4	About 13·6 est. Certainly not so bright as *m*.
18	10 26	115	$m+2$ ...	13·3	13·3	
30	11 20	115	$k+3$; $m-11$	12·0 12·0	12·0	
July 18	10 37	115	$g+6$; $h-2$...	11·0 11·0	11·0	About 11 mag. est.
Oct. 1	8 55	191	$g+6$; $h-2$...	11·0 11·0	11·0	Careful comparison.
1888.						
Mar. 21	8 15	191	Not seen; less than *l*	$<12·6$	$<12·6$	12^h past meridian.
May 1	11 30	191	... ...	13·5 est.	13·5 est.	Well seen.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1888. May 10	h m 10 20	110	$m+4$ ...	13·5	13·5	S about equal to small star n.* About 13·5. Some 3 or 4 tenths less than m.
23	10 15	115	$m+3+4$ ...	13·4 13·5	13·45	13·5 ±.
Aug. 13	8 45	115	$g+8$; $=h$ ...	11·2 11·2	11·2	Slightly ruddy.
Oct. 5	8 10	115 191	Not seen ...	Under 13·1	< 13·1	m well seen.
23	8 40	191	Glimpsed once or twice	14 ±	14 ±	13·7–14 est. n 13·5 (near c) well seen.
Nov. 13	8 20	191	Not seen ...	Under 13·5	< 13·5	m (13·1) and n (13·5) well seen.
Dec. 6	7 30	191	Not seen ...	Under 13·5	< 13·5	m seen. n at times.
26	7 50	191	... ...	Under 13·7	< 13·7	Qu. glimpsed once or twice? 14? 14½? m and n well seen.
1889. Jan. 27	8 30	115	Not seen ...	Under 12	< 12	k seen. Stars rather low, and sky not quite clear.
Feb. 4	9 0	115 191	Not seen ...	Under 12·7 13·0	< 12·7 13·0	l and m seen. n glimpsed? 10ʰ past meridian.
Sept. 6	8 40	115 191	Not seen ...	Under 13·1	< 13·1	m seen.
Oct. 21	9 33	191	Not seen ...	Under 13·5	< 13·5	n seen.
25	7 40	191	Not seen ...	Under 13·7	< 13·7	m and n seen.
Nov. 12	7 50	115 191	Not seen ...	Under 13·7	< 13·7	m and n well seen.
30	8 30	115 191	Not seen ...	Under 13·5	< 13·5	n well seen.
1890. Apr. 4	8 20	115	$=g$	10·4	10·4	11ʰ from meridian, but fairly seen.
22	10 35	70 115	$c+8$; $e+3$...	9·8 9·8	9·8	Ruddy.
29	10 17	70 115	$e+5$; $g-4$...	10·0 10·0	10·0	
Sept. 8	10 57	115	Not seen ...	Under 13·5	< 13·5	m well seen.
Oct. 25	8 11	115 191	Not seen ...	Under 13·2	< 13·2	
Nov. 4	8 25	115 191	Not seen ...	Under 13·7	< 13·7	
Dec. 1	7 25	191	Glimpsed; 13·8?	13·8	13·8	m and n well seen. S 13¾–14 est.
9	6 51	115 191	Glimpsed ...	13·8 14	13·9	n well seen.
1891. Jan. 1	7 3	115	$l+1$; $m-4$...	12·7 12·7	12·7	
Feb. 8	7 30	115 70	$=f$; $e+3$; $g-6$	9·8 9·8 9·8	9·8	Ruddy. Rather large disc?
10	7 43	115	$e+3$; $=f$ ...	9·8 9·8	9·8	Ruddy. Stars rather low and sky not very clear.
18	8 40	115	$e+1\frac{1}{2}$; $=f-1\frac{1}{2}$	9·65 9·65	9·65	Ruddy.
19	7 13	115	$e+3$; $=f$ ...	9 8 9·8	9·8	Ruddy. Far from meridian and Moon bright. Sky rather hazy.
25	7 23	115	$c+7$; $e+2$; $f-1$	9·7 9·7 9·7	9·7	Ruddy. Rather low but well seen.
27	3	70 115	$e+1·5$; $f-1·5$	9·65 9·65	9·65	Ruddy. Full coloured.

* The star n is shown in a small diagram to be about 3ˢ·2 p and 3′ north of S.

S Cygni—continued.

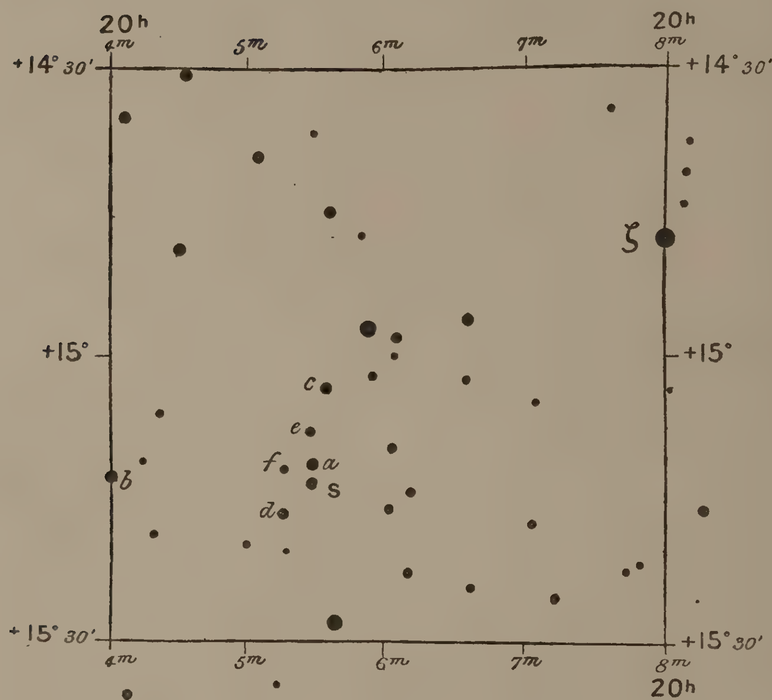
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1891.	h m					
Mar. 26	7 53	70 115	$e+2$; $f-1$ ...	9·7 9·7	9·7	12^h past meridian. Fair observation.
Apr. 6	10 38	115	$e+3$; $=f$ ...	9·8 9·8	9·8	
26	10 22	115	$f+6$; $=g$ ...	10·4 10·4	10·4	
May 7	10 15	115	Glimpsed ...	11 5 ±	11·5 ±	Very doubtful observation. Hazy sky.
Oct. 15	8 25	115	Not seen ...	Under 13·5	< 13·5	m and n seen.
28	7 58	191	... ...	13·7 est.	13·7 est.	Well seen at times. n well seen.
Nov. 3	7 40	115	... ...	13·7 est.	13·7 est.	Obs. rather difficult in clear spaces between clouds.
5	7 50	115	Glimpsed 13·7	13·7	13 7	m and n well seen.
Dec. 17	6 34	115	$h+3$; $k-2$...	11·5 11·5	11·5	Well seen.
19	7 5	70 115	$k-1$; $h+4$...	11·6 11·6	11·6	
1892.						
Jan. 4	7 59	115	$g+4$; $h-4$...	10·8 10·8	10·8	Poor definition. Obs. a little doubtful.
7	6 25	70 115	$f+6$; $g-0-1$	10·4 10·4 10·3	10·4	Slightly ruddy?
15	7 4	115	$f+4$; $g-2$...	10 2 10·2	10·2	
20	7 50	70	$f+0+2$? ...	9·8 10·0	9·9	Difficult observation. Cloudy, hazy sky.
24	6 59	70 115	$e+4$; $f+1$ ...	9·9 9·9	9·9	Slightly ruddy?
Feb. 1	9 0	115	$f+2$; $g-4$...	10·0 10·0	10·0	Slightly ruddy?
13	8 30	115	$f+0+1$; $g-6$	9·8 9·9 9·8	9·83	10^h past meridian.
22	6 55	115	$f+4$; $g-2$...	10·2 10·2	10·2	
27	7 30	115	$f+4$; $g-2$ ...	10·2 10·2	10·2	
Mar. 12	7 45	70 115 200	Not seen at all, nor g	...	...	Moonlight and very hazy sky.
19	7 43	110	$g+7$; $h-1$...	11·1 11·1	11·1	$11\frac{1}{2}^h$ past meridian. Obs. difficult.
Sept. 24	8 58	115 191	$l+4$... ...	13·0	13·0	13 ± est.
Oct. 11	10 12	115 191	$h+4$; $k-1$...	11·6 11·6	11·6	
15	8 51	115	$h+3$; $k-2$...	11·5 11·5	11·5	
22	8 30	70 115	$h+1$; $k-4$...	11·3 11·3	11·3	
Nov. 3	9 5	115	$h+1$... ...	11·3	11·3	Observation a little doubtful.
18	8 15	70	$e+3$; $=f$; $g-6$	9·8 9·8 9·8	9 8	Ruddy.
26	8 55	70	$c+3$; $d-1$...	9·3 9·3	9·3	Ruddy.
30	8 0	70 115	$c+1$; $d-3$...	9·1 9·1	9·1	Orange red. Moon bright.
Dec. 12	6 50	70 115	$=c$; $b+1$ ...	9·0 9 0	9·0	Orange ruddy; so, too, b. c white. S perhaps more decided in tint than b.
30	7 1	70	$c+3$; $e-2$...	9·3 9·3	9·3	Ruddy. Obs. difficult.
1893.						
Jan. 15	6 37	115	$f+2$; $g-4$...	10·0 10·0	10·0	
Feb. 4	7 40	115	$g+10$; $k-3$	11·4 11·4	11·4	
June 30	10 28	191	Not seen ...	Under 13·5	< 13·5	n glimpsed?
Sept. 30	8 55	115	$g+1$ ...	10·5	10·5	Ruddy.

S Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1893.	h m					
Oct. 4	10 2	115	$f+4$; $g-2$ ...	10·2 10·2	10·2	Distinctly ruddy.
12	8 2	70	$f+1$; $g-5$ ...	9·9 9·9	9·9	Decidedly ruddy.
19	7 52	70	$e+3$; $=f$ ...	9·8 9·8	9·8	Very ruddy.
27	7 5	70	$e+2$; $f-1$ ...	9·7 9·7	9·7	Ruddy.
Nov. 6	8 22	70 115	$=f$ or $f-1$ ...	9·8 9·7	9·75	Orange red.
13	8 15	115	$f-1$; $e+2$ ...	9·7 9·7	9·7	Orange ruddy.
Dec. 2	8 10	115	$f+4$; $g-2$ ...	10·2 10·2	10·2	
30	7 30	115 191	$k+3$; $l-6$ ...	12·0 12·0	12·0	Pretty well seen.

Mr. KNOTT'S Diagram, Epoch 1865·0.

S Aquilæ.



Mr. BAXENDELL'S Magnitudes of Comparison Stars (1863).

a = 9·2		*d* = 10·4	
b = 9·4		*e* = 11·0	
c = 10·1		*f* = 12·0	

Mr. BAXENDELL'S Magnitudes of Comparison Stars. (From letter dated 1885 May 20).

a = 9·2	*d* = 10·1
b = 9·4	*e* = 10·8
c = 9·8	

S Aquilæ.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 7242, *S Aquilæ*, R.A. for 1900·0 = $20^h\ 7^m\ 1^s$, Decl. = + 15° 19′·4.
Annual Variation = + $2^s{\cdot}76$ and + 0′·18.
R.A. for 1855·0 = $20^h\ 4^m\ 57^s$, Decl. = + 15° 11′·5.
Redness = 0·8. Max. magnit. = 8·4 − 10·1. Min. = 10·7 − 11·8. Irregular.
$M - m = 72^d$.
Epoch 1865, Nov. 12 = 2402553^d (Julian).
Period $146^d{\cdot}7$.
(From 27 observations of max. and 26 of min., including observations in 1855–91.)

Discovered by Baxendell, 1863. Extraordinary and unexplained irregularities in period. 9^m foll. 1^s, 1′·5 S.

S Aquilæ.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863. Oct. 29·3	h m	60	$a-0-1$ ...	9·2 9·1	9·15	
1864. July 5·5		60	$d+4$; $e-2$...	10·8 10·8	10·8	f 12 mag. Mr. Baxendell's chart.
Aug. 2		60	$d+3$; $e-3$...	10·7 10·7	10·7	
6·3		...	$=d$	10·4	10·4	Bad definition. Mr. Bird suspects S to be a close double, the comes very small.
12·3		60	$a+3+4$; $b+2$; $c-6$	9·5 9·6 9·6 9·5	9·55	Cloudy.
Sept. 23·3		60	$a-1$ ...	9·1	9·1	Fine. Could not make out any minute comes as suspected by Mr. Bird.
24·3		...	$a-0-1$ ...	9·2 9·1	9·15	No sign of comes.
26·3		...	$a-1$ ...	9·1	9·1	In finder $=a$.
27·3		...	$=a$	9·2	9·2	
29·3		...	$=a$	9·2	9·2	
Oct. 3·3		...	$a+0+1$ ...	9·2 9·3	9·25	Between clouds.
Nov. 4·3		...	$e+2+3$ ...	11·2 11·3	11·25	Doubtful. Far from meridian.
1865. May 15·5		60	$e+2$... ...	11·2	11·2	
22·5		60	$e-0-1$ ...	11·0 10·9	10·95	
June 6·5		...	$d+1+2$; $e-4-5$	10·5 10·6 10·6 10·5	10·55	f abt. 12 mag.
19·5		...	$c+2$; $d-1$...	10·3 10·3	10·3	
27·5		60	$=c$	10·1	...	
July 11·4		60	$=c$	10·1	10·1	
19·4		...	$c+3$; $d+1$; $e-5$	10·4 10·5 10·5	10·5	Clear.
25·4		...	$d+3$; $e-3$...	10·7 10·7	10·7	f abt. 12 mag.
26·4		...	$c+3+4$; $d+2$; $e-4$	10·4 10·5 10·6 10·6	10·5	
28·5		60	$d+4$; $e-2$...	10·8 10·8	10·8	
Aug. 1·4		60	$e-0-1$ ...	11·0 10·9	10·95	
5·5		60 191	$e-0-1$ ...	11·0 10·9	10·95	Comp. star b duplex. Discovered by Mr. Bird.
9·4		...	$e+0+1$ ...	11·0 11·1	11·05	
14·4		60	$e+2$... ...	11·2	11·2	
18·4		60	$e+3+4$; $f-6$	11·3 11·4 11·4	11·4	
22·4		60	$e+3+4$; $f-6-7$	11·3 11·4 11·4 11·3	11·35	
30·4		60	$e+4$; $f-6$...	11·4 11·4	11·4	
Sept. 7·4		60	$=e$	11·0	11·0	Moonlight and hazy.
12·3		60	$e+1+2$ ...	11·1 11·2	11·15	
14·3		60	$e-1-2$; $c+7+8$	10·9 10·8 10·8 10·9	10·85	

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865. Sept. 18·3	h m	60	$e-1-2$ ...	10·9 10·8	10·85	
22·4		60	$d+3$; $e-3$...	10·7 10·7	10·7	
Oct. 3·4		70	$d+1$; $e-5$...	10·5 10·5	10·5	
13·3		70	$=d$; $e-7$ ...	10·4 10·3	10·35	
20·3		70	$=d$	10·4	10·4	
Nov. 1·3		60 70	$a+7$; $c-1-2$	9·9 10·0 9·9	9·9	
3·3		70	$a+5$; $b+3$; $c-2$; $d-7$	9·7 9·7 9·9 9·7	9·75	
13·3		60	$a+3$; $b+1$; $d-7$	9·5 9·5 9·7	9·6	
15·3		...	$a+3$; $c-6$...	9·5 9·5	9·5	
18·3		70	$a+2$ ...	9·4 9·4	9·4	
29·3		70	$a+4$; $d-7$...	9·6 9·7	9·65	
Dec. 1·3		70	$a+4$; $c-4$...	9·6 9·7	9·65	4^h past meridian. Definition poor.
14·3		...	$=c$; $d-2$ ...	10·1 10·2	10·15	
30·3		70	$d+1$; $e-5$...	10·5 10·5	10·5	
1866 Jan. 6·3		70	$d+3$; $e-3$...	10·7 10·7	10·7	
May 4·5		...	$a+3$; $c-6$...	9·5 9·5	9·5	
16·4		70	$c+1$; $d-2$...	10·2 10·2	10·2	
19·4		70	$c+2$; $d-1$...	10·3 10·3	10·3	
June 7·5		70 89	$d+2$; $e-4$...	10·6 10·6	10·6	
14·4		70	$d+3$; $e-3$...	10·7 10·7	10·7	
22·4		70	$c+3$; $d-0-1$; $e-7$	10·4 10·4 10·3 10·3	10·35	
25·4		70	$c+1$; $d-2$...	10·2 10·2	10·2	
July 9·4		70	$a+1$; $b-1$...	9·3 9·3	9·3	Slightly ruddy.
10·5		70	$a+0+1$ ...	9·2 9·3	9·25	Decidedly ruddy.
14·4		70	$a-1$... ...	9·1	9·1	Slightly ruddy?
19·4		70	$a+1$? ...	9·3?	9·3?	Clouds troublesome. *S* ruddy.
20·5		70	$a+1$... ...	9·3	9·3	Slightly ruddy?
Aug. 3·4		70	$a+4$; $c-5$...	9·6 9·6	9·6	
9·4		70 89	$a+7$; $c-2$...	9·9 9·9	9·9	In the meridian; *S* ruddy.
16·4		70 102	$a+4$; $c-5$...	9·6 9·6	9·6	Ruddy decidedly.
21·4		70	$a+1$... ...	9·3	9·3	Ruddy. Bright moonlight. Def. good. Good obs. *S* brightening up again.
27·4		70 173	$a-2-3$ ...	9·0 8·9	8·95	Ruddy orange. Bright moonlight.
31·5		70	$a-3$... ...	8·9	8·9	Ruddy. Good definition.
Sept. 11·3		70	$a-2$... ...	9·0	9·0	Decidedly ruddy. When oppressed by clouds. $a > S$.
14·3		70	$a+1$... ...	9·3	9·3	Past max.? Gauged mags. of comp. stars in finder $a=9·0$; $c=9·9$; $d=10·4$; $e=10·9$.

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866. Sept. 24·4	h m	70	$a+2$	9·4	9·4	Ruddy.
Oct. 8·3		70	$c+1$; $d-2$...	10·2 10·2	10·2	
13·3		60	$c+0+1$; $d-3$	10·1 10·2 10·1	10·1	
22·3		60	$c+1$; $d-2$...	10·2 10·2	10·2	Bright moonlight. Comp. star *a* hidden by bar in e.p.
Nov. 3·3		60	$d+3$; $e-3$...	10·7 10·7	10·7	Comp. star *a* hidden by bar of e.p. Vision confused.
6·3		60	$d+3$; $e-3$...	10·7 10·7	10·7	Sky clear. *a* hidden by bar.
13·3		60	$e-0-1$; $d+5$	11·0 10·9 10·9	10·9	*a* hidden by bar.
19·3		60	$d+4$; $e-2$...	10·8 10·8	10·8	*a* hidden by bar.
27·3		60	$=d$	10·4	10·4	Obs. a little doubtful as star far from meridian and haze troublesome. *S* is certainly considerably $>e$. *a* hidden by bar in eye-piece.
Dec. 7·3		60	$c+1$; $d-2$...	10·2 10·2	10·2	5^h past meridian. Wind high, S.W., and definition bad. Obs. rather doubtful. *a* hidden behind bar of e.p.
19·3		70	$d+1(+2?)$...	10·5 10·6	10·55	6^h G.M.T. Moonlight.
26·25		60 70	$c+1+2$; $d-2-1$	10·2 10·3 10·2 10·3	10·25	$4\frac{1}{2}^h$ past meridian. Pretty clear. *a* hidden by bar.
30·25		60	$a+8$; $c-1$; $d-3-4$	10·0 10·0 10·1 10·0	10·0	*a* hidden by bar in eye-piece.
1867. Jan. 4·3		60 89	$a+1+2$ ...	9·3 9·4	9·35	Slightly ruddy.
8·3		70	$a-1-2$ ...	9·1 9·0	9·05	Certainly brighter than *a*; 6^h past meridian.
11·25		60 70	$a-4-5$; $a-4$ with 5-inch aperture	8·8 8·7 8·8	8·8	$6^h\ 10^m$ G.M.T. *S* fine orange red. I should estimate it about $8\frac{3}{4}$ mag. Defn. execrable. Stars flaring. Wind N. by E. A sharp frost.
12	7 0	70 89	Some 5 tenths $>a$	8·7	8·7	$6\frac{1}{2}^h$ past meridian and defn. poor. *c* and *d* seen at times.
14	6 20	60 70	$a-5$... ...	8·7	8·7	Assuming $c-a=9$, then $a-S=5$. *S* ruddy orange. Clear, but defn. rather poor. $5\frac{3}{4}^h$ past merid.
Apr. 29	12 ±	70 89	$e+3$; $f-7$...	11·3 11·3	11·3	$5\frac{1}{2}^h$ from merid.
May 3	12 20 ±	70 89	$e+2+3$ ...	11·2 11·3	11·25	
7	12 30 ±	70 89	$e+2+3$ ...	11·2 11·3	11·25	
21	11 0	...	$c+2$; $d-1$...	10·3 10·3	10·3	*a* shaded by bar in e.p.
23	12 0	70	$c+2$; $d-1$...	10·3 10·3	10·3	More than 0·3 difference between *c* and *d*? 4-inch aperture.
24	12 45	60 70	$a+6$; $c-3$; $d-6$	9·8 9·8 9·8	9·8	$4\frac{1}{2}$-inch aperture. *a* hidden by bar in e.p. for comparison of *S* with *c* and *d*.
30	14 0	70	$a+4$; $c-5$...	9·6 9·6	9·6	3·7-inch aperture.
June 1	13 40	70	$a-0-1$ ...	9·2 9·1	9·15	$7\frac{1}{2}$ and 5-inch aperture. Slightly ruddy.
4	11 20	70	$=a$	9·2	9·2	Slightly ruddy?

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
June 10	12 35	70	$a+1{\cdot}5+2$ ...	9·35 9·4	9·4	
26	12 —	70	$a+2+3?$ ...	9·4 9·5	9·45	Decidedly ruddy. *At times but little fainter than a.* So Mrs. Knott. A difficult star to observe.
28	11 —	70	$a+2+3;\ c-7$	9·4 9·5 9·4	9·4	Pale clear red, or slightly orange red. 5-inch aperture.
July 4	11 —	70 89	$a+3+4;\ c-5$	9·5 9·6 9·6	9·6	5-inch aperture. *S* ruddy?
5	11 50	70	$a+3+4;\ c-5$	9·5 9·6 9·6	9·6	Slight ruddy cast? 5-inch aperture.
9	11 10	89	$a+5+6;\ c-3-4$	9·7 9·8 9·8 9·7	9·75	Slightly ruddy? 5-inch aperture.
16	11 20	70	$a+6;\ c-3;\ d-6$	9·8 9·8 9·8	9·8	Ruddy. 5-inch aperture.
27	11 ±	60 70 89	$=c;\ d-3$ ...	10·1 10·1	10·1	Decidedly red.
31	10 —	60	$c+1;\ d-2$...	10·2 10·2	10·2	*a* hidden by bar. Hazy. Obs. rather doubtful. 5-inch aperture.
Aug. 2	11 30	60	$c+2;\ d-1$...	10·3 10·3	10·3	5-inch aperture. *a* hidden by bar.
9	10 40	60	$d+2+1;\ e-4-5$	10·6 10·5 10·6 10·5	10·55	5-inch aperture. *a* hidden by bar.
12	10 50	60	$d+1;\ e-5$...	10·5 10·5	10·5	5-inch aperture. Bright moonlight.
20	9 ±	60	$d+5+6;\ =e$	10·9 11·0 11·0	11·0	5-inch aperture. *a* concealed by bar.
21	13 40	70	$d+5;\ e-1$...	10·9 10·9	10·9	
Sept. 3	10 30	60	$d+5+6;\ =e$	10·9 11·0 11·0	11·0	Hazy at times. *a* concealed by bar.
4	8 20	60	$=e;\ e+1?$...	11·0 11·1	11·05	Not brighter than *e*, possibly slightly less. 5-inch aperture.
10	10 10	60	$d+4+5;\ e-1-2$	10·8 10·9 10·9 10·8	10·85	Full aperture. *S* brighter than when last observed. *a* hidden by bar.
Oct. 5	7 —	60 70 89	$=e;\ (e-?)$...	11·0	11·0	Haze and cloud troublesome.
19	7 45	70	$a+3;\ c-6$...	9·5 9·5	9·5	3-inch aperture.
Nov. 2	8 50	70	$a-1-0$ ...	9·1 9·2	9·15	Full aperture and also 3·7-inch aperture. Hazy.
5	7 45	70	$a-2$... ...	9·0	9·0	5-inch aperture. Bright moonlight. *S* certainly $>a$.
13	7 40	70	$a-1-2$ ...	9·1 9·0	9·05	5-inch aperture. *S* ruddy.
23	7 45	70 89	$a+2+3$ ...	9·4 9·5	9·45	5-inch aperture. Obs. doubtful on account of flying haze—cloud from N. by E. I think, however, that *S* is certainly $<a$.
Dec. 2	6 15	70	$a+4;\ +3?\ c-5$	9·6 9·5? 9·6	9·6	Cold. Snow on ground. Wind high from N.W. Bad defn. Obsd. with full aperture and also with 3·7-inch aperture.
4	9 0	60	$a+4;\ c-5?$	9·6 9·6	9·6	6^h past meridian Obs. a little doubtful.
7	7 40	60	$a+8;\ c-1$...	10·0 10·0	10·0	Bright moonlight, and sky not quite clear. Snow during the day and star nearly 5^h past meridian.

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867. Dec. 12	h m 6 15	60	$a+7$; $c-2$...	9·9 9·9	9·9	4-inch aperture on object glass. *a* concealed by bar of eye-piece. A high wind from N.W., but clear. Moon rising.
18	7 30	60	$c+2$; $d-1$...	10·3 10·3	10·3	4-inch aperture. Comp. star *a* hidden by bar in eye-piece.
26	6 55	70	$d+1$; $e-5$...	10·5 10·5	10·5	$c=d-3$ I think. A low mist on ground and a white frost. Obs. perhaps a little doubtful.
1868. May 14	11 25	70 89	$d-2$; $a+10$	10·2 10·2	10·2	Slightly ruddy?
18	11 0	60	$c+1$; $d-2$?	10·2 10·2	10·2	*a* concealed by bar of eye-piece. Far from meridian and hazy. Obs. rather doubtful.
23	11 5	70	$c+3$; $=d$ ...	10·4 10·4	10·4	Clear.
26	11 30	60	$c+2$; $d-1$...	10·3 10·3	10·3	
June 5	10 50	89	$=d$? ...	10·4	10·4	Rather doubtful. Moonlight.
13	11 0	60 70	$d+3$; $e-3$...	10·7 10·7	10·7	Haze troublesome.
17	11 20	60	$d+2·5$; $e-3·5$	10·65 10·65	10·65	*a* hidden by bar of eye-piece.
23	11 40	70	$d+1$; $e-5$...	10·5 10·5	10·5	Clear and still.
29	11 5	60	$d+1$; $e-5$...	10·5 10·5	10·5	Careful obs. *a* hidden by bar of eye-piece. The light-estimates written down before I noticed them to be identical with those of the 23rd.
July 13	10 40	60	$c+1$; $d-2$...	10·2 10·2	10·2	*a* hidden by bar of eye-piece. Fair obs.
20	10 55	60	$a+7$; $c-2$; $d-5$	9·9 9·9 9·9	9·9	
25	10 30	60	$a+6+7$; $c-2$	9·8 9·9 9·9	9·9	Obs. very doubtful. Clouds and bad definition.
Aug. 3	10 20	60 191	$a+3$; $c-6$...	9·5 9·5	9·5	Slight orange tint?
8	10 40	70	$a+2$; $=b$ ...	9·4 9·4	9·4	Among clouds.
10	12 20	70 89	$=a$	9·2	9·2	$c>10·1$? Moon rising.
Sept. 5	10 15	70	$a+1$; $+0$?...	9·3 9·2?	9·25	Slight orange tint as compared with *a*. *b* certainly not so bright as $9^{m}·4$, some 3 or 4 tenths less.
30	7 10	70	$a+3$; $b+1$; $c-6$	9·5 9·5 9·5	9·5	Fair observation.
Oct. 7	8 15	60	$a+5$; $b+3$; $c-4$	9·7 9·7 9·7	9·7	5-inch aperture. Bar eye-piece.
23	7 55	60	$=c$; $d-3$ ...	10·1 10·1	10·1	Decidedly ruddy. Moonlight.
Nov. 2	8 40	60	$c+1$; $d-2$...	10·2 10·2	10·2	Fair obs. Moonlight.
5	8 20	60	$c-1$; $d-4$...	10·0 10·0	10·0	Careful obs. *a* concealed by bar. Observed with full aperture and also with aperture of 4 inches.
Dec. 19	7 35	60	$c+2$; $d-1$...	10·3 10·3	10·3	*a* hidden by bar. $5\frac{1}{4}^{h}$ past meridian.
23	7 10	60	$c+1$; $d-2$...	10·2 10·2	10·2	*a* concealed by bar of eye-piece.

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Jan. 5	h m 7 15	70 89	$=a$	9·2	9·2	6^h past meridian and rather *flaring*. *S* a pale coppery orange. A very delicate tint.
15	11 15	70	$a-3$... ...	8·9	8·9	Very decidedly ruddy.
17	10 55	70 89	$a-4$... ...	8·8	8·8	Decided clear copper red. Steady. Moonlight.
29	12 25	70 89	$a-1-2$? ...	9·1 9·0	9·05	Coppery red.
July 10	11 5	70	$=a$; $a+0·5$?	9·2 9·25	9·2	Slightly ruddy. Hazy. 5-inch aperture.
23	11 0	70	$a+2$; $c-7$...	9·4 9·4	9·4	Ruddy. Bright moonlight.
Aug. 6	10 45	60	$d+1$; $e-5$...	10·5 10·5	10·5	*a* concealed by bar of eye-piece. *S* slightly ruddy. Aperture reduced to 5 inches.
12	10 25	70	$e+0+1$ ...	11·0 11·1	11·05	Good obs. Moonlight.
17	10 20	89	$d+6$; $=e$ ...	11·0 11·0	11·0	Good obs. Moonlight.
24	8 33	89 191	$e+5$; $f-5$...	11·5 11·5	11·5	Careful comparison.
Sept. 20	10 45	89	$e+4$; $f-6$...	11·4 11·4	11·4	Fair observation.
Oct. 9	7 17	89?	$e+3$; $f-7$...	11·3 11·3	11·3 }	Good observation.
		70	$=e$	11·0	11·0 }	Vision rather unsteady.
26	6 55	89	$a+8$; $c-1$; $d-4$	10·0 10·0 10·0	10·0	Brilliant, but bad definition.
Nov. 4	10 10	70	$a+4$; $c-5$...	9·6 9·6	9·6	Obs. rather doubtful. Star 5^h past meridian and defn. poor. High wind N.W.
6	7 30	89	$a+3$; $c-6$...	9·5 9·5	9·5	*S* rather hazy? 3·7-inch aperture.
10	7 0	70	$a+2+3$? ...	9·4 9·5	9·45	*S* rather dull? Bluish?
11	7 0	70	$a+3$; $c-6$ ..	9·5 9·5	9·5	Dull grey?
20	6 30	89 191	$a+4$; $c-5$...	9·6 9·6	9·6	3·7-inch aperture. Obs. a little uncertain and star perhaps rather underrated.
30	7 25	60	$a+4$; $b+2$; $c-5$	9·6 9·6 9·6	9·6	$9\frac{1}{2}$ est. Bar eye-piece.
Dec. 24	6 15	70	$d+3$; $e-3$...	10·7 10·7	10·7	Clear. Confused vision. Wind N.N.E.
1870. June 6	11 30	89	$e+4$; $f-6$...	11·4 11·4	11·4	Unsteady vision.
20	12 5	89	$e+5$; $f-5$...	11·5 11·5	11·5	
Oct. 15	8 20	60	$c+2$; $d-1$...	10·3 10·3	10·3	*a* hidden by bar of eye-piece.
26	7 30	60	$=d$; $c+3$ ...	10·4 10·4	10·4	Good obs. *a* hidden by bar of eye piece.
Dec. 29	6 30	89	$a+6$; $c-3$...	9·8 9·8	9·8	Defn. poor. A severe frost. Ink frozen in observatory.
1871. June 5	11 10	70	$a-1$... ...	9·1	9·1	Decidedly ruddy.
26	11 10	70	$a+1$... ...	9·3	9·3	Ruddy. *b* less than 9·4 I think.
July 22	11 10	70 115	$a+1$... ...	9·3	9·3	Slight ruddy tinge.
29	10 35	115	$a+2$... ...	9·4	9·4	Certainly ruddy. Moonlight.
Aug. 15	11 24	115	$d-0-1$ ...	10·4 10·3	10·35	
31	11 0	70 115	$d+4$; $e-2$...	10·8 10·8	10·8	

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871.	h m					
Sept. 9	10 55	70 115	$e+0+2$ ...	11·0 11·2	11·1	Obs. a little uncertain. Clouds about.
Oct. 9	10 21	70 115	$c+3;\ =d$ ...	10·4 10·4	10·4	Clear.
23	8 35	70	$=a$	9·2	9·2	Certainly ruddy.
25	8 35	70	$=a;\ a-1$?...	9·2 9·1	9·15	Bright moonlight and haze. *S* slightly ruddy.
Nov. 18	6 45	70	$a+0+1$ ...	9·2 9·3	9·25	Orange red. Moonlight.
29	6 55	70 115	$a-1-2$ ...	9·1 9·0	9·05	Ruddy. Decidedly brighter than *a*.
Dec. 4	8 35	70	$=c;\ c-1$?...	10·1 10·0	10·05	Perhaps a tenth greater than *c*. Orange tint.
29	5 35	70 115	$=d;\ d-1;\ c+2$	10·4 10·3 10·3	10·3	Clear sky.
1872.						
Jan. 6	6 40	115	$d+4;\ e-2$ ...	10·8 10·8	10·8	Star low and obs. a little uncertain.
May 27	12 45	115	$=d$	10·4	10·4	10½ est.
June 13	11 55	115	$e+5$... ...	11·5	11·5	11·5 est.
29	11 30	115	$e+6;\ f-4$ ...	11·6 11·6	11·6	11½ est.
Aug. 28	10 30	70 115	$a+2$... ...	9·4	9·4	Twinkles rather.
31	10 40	115	$a+1$... ...	9·3	9·3	Slightly ruddy.
Sept. 5	8 45	70	$=a$	9·2	9·2	I think certainly *not less than a*, but obs. interrupted by clouds.
16	11 10	70	$=a;\ a-1$?...	9·2 9·1	9·15	Slightly ruddy?
21	10 20	115	$a+2+1$ ...	9·4 9·3	9·35	Ruddy. Vision rather confused.
Oct. 7	10 30	60	$a+8;c-1;d-4$	10·0 10·0 10·0	10·0	Slightly ruddy.
22	8 55	115	$d+1;\ e-5$...	10·5 10·5	10·5	Obs. a little doubtful.
28	10 20	70	$d+2;\ e-4$...	10·6 10·6	10·6	In clear intervals between haze.
Nov. 12	9 0	70	$=e$? ...	11·0	11·0	A little doubtful. Moonlight.
23	8 10	115	$e+3;\ f-7$ ...	11·3 11·3	11·3	
1873.						
Jan. 2	6 50	70	$a+2;\ =b$ ...	9·4 9·4	9·4	Nearly equal to *a*.
1876.						
Nov. 29	7 30	70	$=e$	11·0	11·0	Well seen.
1877.						
May 4	12 0	70	$=e$	11·0	11·0	
15	12 30	70	$d+1;\ e-5$...	10·5 10·5	10·5	Well seen. 4^h from meridian.
June 9	10 40	70	$a-1-2;\ b-4$	9·1 9·0 9·0	9·0	Decidedly red.
20	10 40	70	$a-1-2;\ b-4$	9·1 9·0 9·0	9·0	Slightly ruddy? Decidedly > *a*. Moonlight and haze.
25	11 50	70	$a-2$... ...	9·0	9·0	Decidedly > *a*. Slightly ruddy?
29	12 0	70	$a-1$... ...	9·1	9·1	Decidedly ruddy.
July 7	11 25	70	$a-1$... ...	9·1	9·1	Decidedly red.
17	11 44	70	$=a$	9·2	9·2	Decidedly ruddy.
26	10 18	70	$=a(=a-??)$	9·2	9·2	Decidedly ruddy.
Aug. 7	11 5	70	$a+1;\ b-1$ ...	9·3 9·3	9·3	Decidedly slightly ruddy.
15	10 35	70 115	$a+3;b+1;c-6$	9·5 9·5 9·5	9·5	Decidedly ruddy. Decreasing.

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877.	h m					
Aug. 17	10 25	70	$a+3$; $c-6$...	9·5 9·5	9·5	Ruddy. A decided tint.
Sept. 27	11 45	70	$=e$	11·0	11·0	4^h past meridian.
Dec. 10	6 45	70	$a+2$; $=b$ ...	9·4 9·4	9·4	Slightly ruddy.
27	7 3	70	$a+5$; $c-4$...	9·7 9·7	9·7	Clear.
1878.						
Jan. 7	7 40	70	$a+8$; $c-1$??	10·0 10·0	10·0	Clear. $5\frac{1}{2}^h$ past meridian.
May 21	12 30	70	$=a$	9·2	9·2	Ruddy.
June 12	11 0	70	$d+3$; $e-3$...	10·7 10·7	10·7	Clear sky. High S.W. wind.
July 13	11 17	70	$d+3$; $e-3$ ...	10·7 10·7	10·7	Intermediate in mag. between d and e.
Aug. 1	12 15	70	$=c$; $d-3$ ...	10·1 10·1	10·1	
Oct. 14	10 20	115	$c+2$; $d-1$...	10·3 10·3	10·3	
Nov. 16	7 0	115	$e-0-1$ ...	11·0 10·9	10·95	Fairly clear.
1879.						
July 24	11 45	70	$a+2$; $=b$ ...	9·4 9·4	9·4	
Aug. 6	10 10	70 115	$a+7$;$c-2$;$d-5$	9·9 9·9 9·9	9·9	Ruddy?
Oct. 4	8 40	115	$e+6$; $f-4$...	11·6 11·6	11·6	Cloudy at times.
11	7 50	89	$e+4$; $f-6$...	11·4 11·4	11·4	Clear sky. Still.
Nov. 12	8 30	70	$a+3$; $c-6$...	9·5 9·5	9·5	
1880.						
Aug. 10	11 18	70	$a+5$; $c-4$...	9·7 9·7	9·7	
31	8 40	70	$a+5$;$b+3$;$c-4$	9·7 9·7 9·7	9·7	Slightly ruddy.
Sept. 24	8 45	70	$a+1$; $b-1$...	9·3 9·3	9·3	Not quite so bright as a. No decided colour.
29	7 35	70	$a+3$... ...	9·5	9·5	
Oct. 11	8 20	70 115	$a+3$; $c-7$...	9·5 9·4	9·45	Slight orange tint.
23	8 30	115	$c+2$; $d-2$...	10·3 10·2	10·25	Cloud troublesome.
Nov. 19	8 40	115	$c+3$; $=d$; $e-6$	10·4 10·4 10·4	10·4	Well observed.
25	8 40	70	$d+3$; $e-3$...	10·7 10·7	10·7	
1881.						
Jan. 3	6 30	70	$a+2$; $c-7$...	9·4 9·4	9·4	Decidedly ruddy.
7	6 53	70	$a+1$... ...	9·3	9·3	Nearly equal to a.
Aug. 4	10 15	70	$a+5$; $c-4$...	9·7 9·7	9·7	Hazy. (A thick ground mist came over, rapidly hiding all but one or two of the brighter stars near the zenith.)
Sept. 26	7 23	70	$e+0+2$; $f-8-10$	11·0 11·2 11·2 11·0	11·1	Obs. a little uncertain.
30	8 27	70	$=e$	11·0	11·0	
Oct. 4	9 7	70	$d+3$; $e-3$...	10·7 10·7	10·7	
15	9 5	115	$d+3$; $e-3$...	10·7 10·7	10·7	S ruddy orange?
19	8 30	115	$d+2$; $e-4$...	10·6 10·6	10·6	Distinctly orange tint.
Nov. 15	8 15	70	$a+3+4$; $c-6$	9·5 9·6 9·5	9·5	
17	7 5	70	$a+3$; $c-6$...	9·5 9·5	9·5	

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881.	h m					
Nov. 23	8 55	70	$a+2$? ...	9·4?	9·4?	
28	8 53	70	$=a$; $(a+??)$	9·2	9·2	Moonlight. Fair observation.
Dec. 3	7 30	70	$a-1$... ...	9·1	9·1	Orange tint. Moonlight and clouds.
5	8 47	70	$a-0-1$ ...	9·2 9·1	9·15	Slightly ruddy?
8	7 17	70	$=a$	9·2	9·2	Decided ruddy tint.
13	7 18	70	$a+1$; $b-1$...	9·3 9·3	9·3	With full aperture and with 3·7 inch ap. Barely $=a$. Orange tint.
20	6 50	70	$a+3;b+1;c-6$	9·5 9·5 9·5	9·5	Clear, but a gale blowing.
23	7 0	70	$a+4;b+2;c-5$	9·6 9·6 9·6	9·6	Hazy.
29	6 45	70	$a+4;c-5;b+2$	9·6 9·6 9·6	9·6	
1882.						
Jan. 4	6 40	115	$a+9$; $=c$ ...	10·1 10·1	10·1	
7	6 45	115	$c+3$; $=d$; $e+6$	10·4 10·4 10·4	10·4	Clear, wind high.
June 15	10 36	115	$e+5$; $f-5$ ...	11·5 11·5	11·5	Well seen.
July 24	10 45	115	$e+3$; $f-7$ ...	11·3 11·3	11·3	Hazy.
Aug. 9	10 27	70	$c+1$; $d-2$...	10·2 10·2	10·2	
Oct. 2	8 7	115	$a+1$... ...	9·3	9·3	Slightly but decidedly less than a.
23	7 50	89	$d+2$; $e-4$ ...	10·6 10·6	10·6	Decidedly less than d when a is hidden.
Nov. 9	8 40	70	$e+3$; $f-7$ ...	11·3 11·3	11·3	
17	6 58	115	$e+7$; $f-3$ ...	11·7 11·7	11·7	
28	6 1	110	$e+5$; $f-5$ ...	11·5 11·5	11·5	Clear sky.
1883.						
June 15	10 57	115	$a+3$; $c-6$...	9·5 9·5	9·5	Ruddy.
28	10 55	...	$=a$; $a-1$?...	9·2 9·1	9·15	In finder about equal.
July 4	11 9	70	$a+1$... ...	...	9·3	Ruddy. Certainly rather less than a.
13	10 38	70	$a+3$; $c-6$...	9·5 9·5	9·5	Ruddy.
23	10 20	70	$a+5$; $c-4$...	9·7 9·7	9·7	(A heavy bank of clouds prevents obs. of *S Virginis* and *R Scorpii*. A long succession of cloudy nights.)
28	10 7	115	$=c$; $d-3$ ...	10·1 10·1	10·1	
Aug. 21	8 55	115	$d+3$; $e-3$...	10·7 10·7	10·7	
Oct. 2	7 30	70	$a+5$; $c-4$...	9·7 9·7	9·7	
27	8 45	70	$a+7$; $c-2$...	9·9 9·9	9·9	3-inch aperture on telescope.
29	7 15	70	$a+5$; $c-4$...	9·7 9·7	9·7	3-inch aperture on telescope.
Nov. 17	7 40	115	$a+2$... ...	9·4	9·4	Orange tint.
26	8 0	70	$=a$	9·2	9·2	Slight orange tint.
1884.						
June 30	11 5	70	$c+1$; $d-2$...	10·2 10·2	10·2	Ruddy.
July 17	11 11	70	$c+0+1$; $d-2-3$	10·1 10·2 10·2 10·1	10·15	Orange ruddy.
Aug. 1	10 45	70	$=d$	10·4	10·4	
22	9 0	70 115	$=d$	10·4	10·4	
Oct. 4	8 10	70	$a+2$; $=b$ ...	9·4 9·4	9·4	Ruddy.

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884.	h m					
Oct. 13	8 0	70	$a+2$... ...	9·4	9·4	Ruddy.
21	8 12	70	$a+2$... ...	9·4	9·4	b rather brighter than a??
28	8 43	70	$a+2$... ...	9·4	9·4	Ruddy. b three tenths less than a—decidedly less. $S1>b$.
Nov. 7	8 35	70	$a+1$... ...	9·3	9·3	Orange tint. Barely $=a$. So too in finder.
15	8 0	70	$=a$	9·2	9·2	Ruddy orange.
19	8 0	70	$a-0-1$ ...	9·2 9·1	9·15	Orange tint. Equal to or slightly brighter than a.
28	8 3	70	$a-1$... ...	9·1	9·1	Slightly ruddy. Certainly slightly brighter than a.
Dec. 4	8 17	70	$a+3$... ...	9·5	9·5	
9	7 27	115	$a+8$; $c-1$ ...	10·0 10·0	10·0	
1885. Jan. 7	6 15	115	$d+4$; $e-2$ ...	10·8 10·8	10·8	
May 15	11 20	110	$d+1$; $e-5$ ...	10·2 10·3 (Mr. Baxendell's new value of comp. stars in letter dated 1885 May 20.)	10·25	5^h from meridian.
June 1	11 20	110	$=e$?... ...	10·8	10·8	Hazy, and 4^h from meridian. A little doubtful. Moon rising.
17	10 50	115	A tenth or so fainter than e, much $>f$	11·0 ±	11·0 ±	
July 10	11 30	110	$b+2$; $c-2$ ...	9·6 9·6	9·6	No decided tint. Not ruddy.
13	11 10	70	$=c$?... ...	9·8?	9·8?	Slightly ruddy.
17	10 26	70	$a+2$; $=b$ ...	9·4 9·4	9·4	Slightly ruddy?
20	10 40	115	$a+2$; $=b$ ...	9·4 9·4	9·4	Slight orange yellow?
24	11 0	70	$a+1$; $b-1$ ...	9·3 9·3	9·3	Orange yellow?
Aug. 10	12 3	70 115	$a+3$; $b+1$; $c-3$	9·5 9·5 9·5	9·5	Slightly ruddy.
27	9 50	70	$a+3$; $b+1$; $c-3$	9·5 9·5 9·5	9·5	Decidedly ruddy.
29	9 45	115	$a+3+4$; $c-3-2$; $b+1+2$	9·5 9·6 9·5 9·6 9·5 9·6	9·55	
Oct. 1	8 25	115	$e+3$... ...	11·1	11·1	
7	8 25	115	$e+6$; $f-6$ ...	11·4 11·4	11·4	
27	7 35	115	$d+4$; $e-3$ ...	10·5 10·5	10·5	
Nov. 17	7 0	115	$=d$	10·1	10·1	*Not brighter* than d.
1886. June 1	11 35	70 115	$a+2$; $=b$ ...	9·4 9·4	9·4	Slight orange tint?
23	11 5	115	$d+3$; $e-4$ ...	10·4 10·4	10·4	Orange tint?

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1886.	h m					
June 30	10 54	115	$d+7; =e; f-12$	10·8 10·8 10·8	10·8	Orange tint.
July 5	10 45	115	$e+2; f-10$...	11·0 11·0	11·0	At times *S* looks nearly equal *e*.
15	11 30	115 200	$\frac{1}{2}(d+e)$ ...	10·45	10·45	Obs. very difficult and result doubtful. Hazy sky illuminated by full Moon.
24	10 30	70 115	$d+4; e-3$...	10·5 10·5	10·5	Ruddy orange tint.
Aug. 10	10 35	115	$d+0+1; e-6$	10·1 10·2 10·2	10·2	Fairly well observed. *S* nearly a magnitude less than *a*.
Sept. 30	8 25	115	$a+1; b-1$...	9·3 9·3	9·3	A tenth or so less than *a*. Orange yellow?
Oct. 2	9 40	115	$=a$	9·2	9·2	
21	8 40	115	$a+2+3; c-3$	9·4 9·5 9·5	9·5	Slight orange tint?
Nov. 2	10 7	115	$c+2; d-1$...	10·0 10·0	10·0	$4\frac{3}{4}^h$ past meridian.
16	8 7	115	$d+4; e-3$...	10·5 10·5	10·5	
29	8 21	115	$d+6; e-1$...	10·7 10·7	10·7	Clear sky.
Dec. 1	7 50	115	$d+7; =e; f-12$	10·8 10·8 10·8	10·8	Slight orange tint?
14	7 50	115	$d+4; e-3$...	10·5 10·5	10·5	5^h past meridian.
16	6 30	70 110	$d+2+3; e-5-4$	10·3 10·4 10·3 10·4	10·35	
18	6 30	60	$=d$	10·1	10·1	*a* hidden by bar in eye-piece.
		115	$a+10; d+1; e-6$	10·2 10·2 10·2	10·2	Clear. Stars not well defined.
25	7 15	115	$=d$	10·1	10·1	Not very clear, and stars rather far from meridian.
30	6 40	115	$=c; c+1; a+7$	9·8 9·9 9·9	9·9	Hazy. Bad definition. Stars observed with difficulty.
1887.						
June 13	11 20	115	$c+2; d-1$...	10·0 10·0	10·0	Orange tint.
18	10 40	70 115	$a+3; c-3$...	9·5 9·5	9·5	Orange tint. Very decided orange tint with 115.
30	10 37	115	$a+0+1$ ...	9·2 9·3	9·25	Ruddy orange tint. *a* white. $=a$ with 70.
July 18	10 50	115	$=a$	9·2	9·2	So too in finder. Orange tint. Decided tint.
21	11 5	115	$=a$	9·2	9·2	So too in finder. *S* orange tint.
Aug. 12	10 15	115	$=d$	10·1	10·1	Obs. troublesome. I think this estimate fair.
22	10 20	70 115	$=e; d+6$ ...	11·0 11·0	11·0	
Oct. 1	8 35	115	$c+3; =d; e-7$?	10·1 10·1 10·1	10·1	Fair obs.
11	8 30	60	$c+2; d-1$...	10·0 10·0	10·0	*a* hidden by bar.
17	8 40	115	$d+2; e-5$...	10·3 10·3	10·3	
19	8 50	115	$d+2; e-5$...	10·3 10·3	10·3	Orange tint?
31	8 10	70	$=c; d-3$ ...	9·8 9·8	9·8	Orange tint.
Nov. 14	7 55	115	$a+1$... ...	9·3	9·3	Orange tint.

S Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887.	h m					
Nov. 30	7 10	115 70	$a+0+1$ ...	9·2 9·3	9·25	With full aperture and aperture reduced to 3·2 inches. *S* orange tint.
Dec. 5	7 5	70	$a+3$; $c-3$...	9·5 9·5	9·5	Rather hazy sky.
15	6 57	70	$a+6$; $=c$; $d-3$	9·8 9·8 9·8	9·8	
1888.						
May 24	11 5	70 115	$a+0+1$; $b-2$	9·2 9·3 9·2	9·2	Orange tint.
Aug. 3	11 0	70	$=d$	10·1	10·1	
13	10 5	115	$d+1$; $e-6$ ...	10·2 10·2	10·2	Orange tint.
13	11 0	70	$b+2$; $c-6$...	9·6 9·2	9·4	Orange red. Observed in telescope and finder.
Oct. 5	8 45	115	$a+6$; $=c$; $d-3$	9·8 9·8 9·8	9·8	Decided orange tint.
11	10 20	115	$a+3$; $c-3$...	9·5 9·5	9·5	Orange tint.
13	8 25	70	$a+4$; $c-2$...	9·6 9·6	9·6	Orange tint.
15	8 10	110	$a+3$; $b+0+1$; $c-3$	9·5 9·4 9·5 9·5	9·5	Ruddy orange.
19	8 28	70	$a+2$; $c-4$; $=b$	9·4 9·4 9·4	9·4	Orange tint.
23	7 47	70 115	$a+1+2$; $b-0-1$; $c-4$	9·3 9·4 9·4 9·3 9·4	9·35	Orange tint.
27	7 50	115 70	$a+2+1$; $c-4-5$	9·4 9·3 9·4 9·3	9·35	Orange tint.
Nov. 3	7 15	70	$a+3$; $c-3$...	9·5 9·5	9·5	Bad definition.
6	7 55	115	$a+3$; $c-3$...	9·5 9·5	9·5	Orange tint.
13	6 50	115	$d+2+1$; $e-5-6$	10·3 10·2 10·3 10·2	10·25	Clear spaces between clouds.
20	7 15	70	$d+5$; $e-2$...	10·6 10·6	10·6	
26	7 45	115	$d+5$; $e-2$...	10·6 10·6	10·6	
28	7 56	115	$d+5$; $e-2$...	10·6 10·6	10·6	
Dec. 6	6 40	115	$d+4$; $e-3$...	10·5 10·5	10·5	
10	6 0	70	$d+4$; $e-3$...	10·5 10·5	10·5	Moonlight and hazy.
12	6 25	115	$d+5$; $e-2$...	10·6 10·6	10·6	
26	7 0	70 115	$d+6$; $e-1$...	10·7 10·7	10·7	
1889.						
Aug. 7	10 10	115	$d+5$; $e-2$...	10·6 10·6	10·6	
Sept. 6	7 52	115	$d+7$; $=e$ ...	10·8 10·8	10·8	Slightly ruddy?
10	8 45	115	$d+6$; $e-1$...	10·7 10·7	10·7	Orange tint?
Oct. 21	9 45	70 115	$a+3$; $c-3$...	9·5 9·5	9·5	
25	7 14	70 115	$a+1+0$ ...	9·3 9·2	9·25	Slight orange tint?
31	7 50	115 70	$=a$	9·2	9·2	Nearly white? as *a*?
Nov. 2	7 10	70 115	$=a$	9·2	9·2	Slight orange tint?
12	7 15	70 115	$=a$	9·2	9·2	Slight orange tint? Perhaps barely equal *a*. Certainly *not brighter* than *a*.
25	6 10	70 115	$=a$	9·2	9·2	Slight orange tint? A careful comparison in telescope and in finder.

S. Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889.	h m					
Nov. 30	7 51	115	$a+1$... ...	9·3	9·3	Slight orange tint.
Dec. 4	6 30	115	$a+2$; $c-4$...	9·4 9·4	9·4	Orange tint.
11	6 25	70 115	$a+4$; $c-2$...	9·6 9·6	9·6	
12	6 30	70 115 191	$a+5$; $c-1$; $d-4$	9·7 9·7 9·7	9·7	
1890.						
Aug. 1	10 10	70	$a+4$; $c-2$...	9·6 9·6	9·6	Decidedly ruddy. Rather difficult to decide on light differences.
4	11 9	70 115	$a+2$; $c-4$...	9·4 9·4	9·4	Orange tint?
5	10 45	70 115	$a+3$; $c-3$...	9·5 9·5	9·5	
23	10 14	70 115	$a+8$; $c+2$; $d-1$	10·0 10·0	10·0	Slight orange tint?
27	9 45	115	$c+2$; $d-1$....	10·0 10·0	10·0	Decidedly slightly ruddy.
30	9 3	115	$c+3$; $=d$ ...	10·1 10·1	10·1	Slight orange tint?
Sept. 4	9 55	70 115	$d+5$; $e-2$...	10·6 10·6	10·6	
8	9 52	70	$e-0-1$ ...	10·8 10·7	10·75	
13	8 17	70 115	$d+2$; $e-5$; $c+7$	10·3 10·3 10·5	10·4	Brightening up again.
15	10 15	70	$c+2$; $d-1$...	10·0 10·0	10·0	
Oct. 25	8 16	70 115	$a+1$... ...	9·3	9·3	No marked colour. Slightly more orange than a?
27	8 10	70	$a+0+1$; $b-1-2$	9·2 9·3 9·3 9·2	9·25	Hazy sky and moonlight.
Nov. 1	6 24	115	$a+2$; $c-4$...	9·4 9·4	9·4	Orange tint.
4	7 33	70 115	$a+3$; $c-3$...	9·5 9·5	9·5	Slight orange tint?
9	7 40	70 115	$a+4$; $d-5$	9·6 9·6	9·6	
10	7 15	70	$a+5$; $c-1$...	9·7 9·7	9·7	Obsn. doubtful. Interrupted by clouds.
10	7 40	70 115	$a+6$; $d-3$	9·8 9·8	9·8	Clear sky now. Light of *S* distinctly ruddy as compared with a and d.
13	7 58	70 89	$c+3$; $=d$ ...	10·1 10·1	10·1	Slight orange tint?
28	6 45	70 115	$=d$; $e-7$ ...	10·1 10·1	10·1	
Dec. 1	6 30	115	$d+1$; $e-6$	10·2 10·2	10·2	Slightly ruddy. Mags. same with 60 and a hidden by bar.
7	6 10	115	$d+4$; $e-3$...	10·5 10·5	10·5	Orange tint.
9	6 0	115 70	$d+6+5$; $e-1-2$	10·7 10·6 10·7 10·6	10·65	Clear. Well seen.
10	7 0	70 115	$d+5+6$; $e-2-1$	10·6 10·7 10·6 10·7	10·65	
12	7 50	115	$d+5$; $e-2$...	10·6 10·6	10·6	Obsn. difficult. 5ʰ past meridian.
13	6 45	70 110 115	$d+4$; $e-3$...	10·5 10·5	10·5	Brightening up?
22	6 0	115	$d+6$; $e-1$...	10·7 10·7	10·7	Hazy sky and moonlight. Good obsn.
1891.						
Jan. 1	6 5	70 115	$d+5$; $e-2$...	10·6 10·6	10·6	

S. Aquilæ—continued.

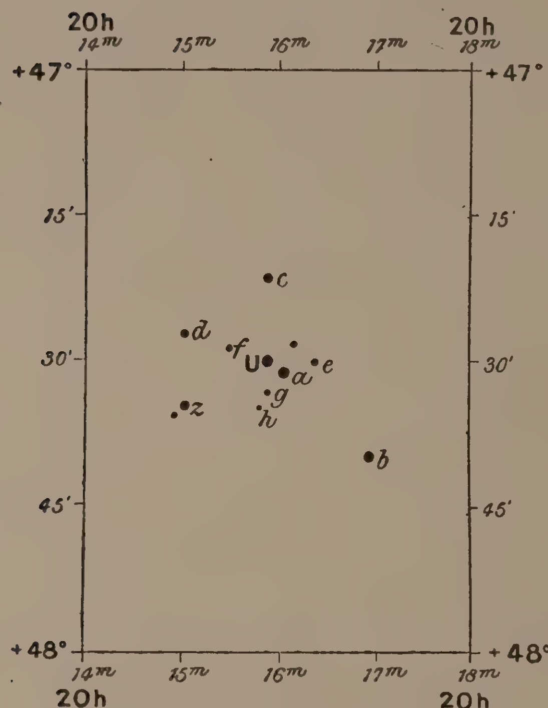
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1891.	h m					
June 5	11 35	115	$c+3$; $=d$ ...	10·1 10·1	10·1	Rather low.
July 28	10 29	70	$c+1$; $d-2$...	9·9 9·9	9·9	
Aug. 10	10 4	70 115	$e-0-1$; $d+6+7$	10·8 10·7 10·7 10·8	10·75	
12	10 18	70 115	$=e$; $d+7$	10·8 10·8	10·8	
Sept. 4	8 10	115	$d+7$; $=e$	10·8 10·8	10·8	
Oct. 12	8 40	70	$d+6$; $e-1$	10·7 10·7	10·7	
15	10 0	115	$d+5$; $e-2$...	10·6 10·6	10·6	
23	8 30	70 115	$c+1$; $d-2$...	9·9 9·9	9·9	Brightening up.
28	7 7	70 115	$a+5$; $c-1$...	9·7 9·7	9·7	Orange ruddy.
Nov. 3	8 0	70 115	$a+1+2+1$...	9·3 9·4 9·3	9·3	Orange tint. When best seen abt. a tenth less than *a*.
5	7 17	70	$=a$	9·2	9·2	Orange tint.
7	8 20	70 115	$a-0-1$ ...	9·2 9·1	9·15	Orange tint. Clouds troublesome.
11	8 37	70	$a-2$... ...	9·0	9·0	Ruddy orange.
Dec. 17	5 55	70 115	$a+4$; $c-2$...	9·6 9·6	9·6	Orange tint.
19	6 33	70 115	$a+6$; $=c$; $d-3$	9·8 9·8 9·8	9·8	Orange tint.
1892.						
Jan. 4	6 35	70 115	$a+3$; $c-3$...	9·5 9·5	9·5	Poor seeing.
7	5 55	70	$a+3$; $c-3$...	9·5 9·5	9·5	Orange tint. Obsd. in clear spaces between snow clouds.
May 30	11 29	70 115	$a+7$; $c+1$; $d-2$	9·9 9·9 9·9	9·9	Orange tint.
July 10	10 27	115	$d+6$; $e-1$...	10·7 10·7	10·7	
28	10 35	70 115	$d+6$; $e-1$...	10·7 10·7	10·7	Slight orange tint.
Aug. 15	10 0	115	$a+4$; $c-2$...	9·6 9·6	9·6	Decided orange tint.
Sept. 24	7 47	115	$a+0+1$ ...	9·2 9·3	9·25	Slight orange tint.
Oct. 11	8 20	70	$a+5$; $c-1$...	9·7 9·7	9·7	Orange tint. Hazy sky.
15	7 55	115	$c+1$; $d-2$...	9·9 9·9	9·9	
17	7 56	70	$c+2$; $d-1$...	10·0 10·0	10·0	Slight orange tint.
20	7 23	115	$c+2$; $d-1$...	10·0 10·0	10·0	Orange tint.
22	7 33	115	$c+3$; $=d$ ...	10·1 10·1	10·1	Orange tint. With 60 and *a* hidden by bar *S* very nearly $=d$. Perhaps slightly brighter.
Nov. 3	8 24	70 115	$d+5$; $e-2$...	10·6 10·6	10·6	Bright Moon and haze.
10	7 15	115	$d+5$; $e-2$...	10·6 10·6	10·6	Fair obn. *S* certainly greater than *e*.
18	7 53	70 115	$d+4$; $e-3$...	10·5 10·5	10·5	
30	6 55	115	$d+5$; $e-2$...	10·6 10·6	10·6	Orange tint?
Dec. 12	6 25	115	$c+2$; $d-1$...	10·0 10·0	10·0	Slight orange tint.
30	6 40	70	$a+3$; $c-3$...	9·5 9·5	9·5	Moonlight, and star far from meridn.
1893.						
June 30	10 50	70 115	$a+0+1$ ...	9·2 9·3	9·25	Slight orange tint.
Aug. 4	10 0	115	$c+1$; $d-2$...	9·9 9·9	9·9	Ruddy orange.

S. Aquilæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1893.	h m					
Aug. 7	10 18	115	$a+5$: $c-1$...	9·7 9·7	9·7	Orange ruddy.
14	10 40	115	$a+3$; $c-3$...	9·5 9·5	9·5	Orange tint.
Sept. 30	8 10	70	$a+0\div 1$ ...	9·2 9·3	9·25	Slight orange tint.
Oct. 4	8 11	70	$a+1$... ...	9·3	9·3	Ruddy orange.
12	7 37	70	$a+1$; $b-1$...	9·3 9·3	9·3	Slight orange tint.
19	7 40	70	$a+2$; $c-4$...	9·4 9·4	9·4	Orange tint.
27	6 31	70	$c+2$; $d-1$...	10·0 10·0	10·0	Orange tint.
Nov. 6	7 53	70	$d+1$; $e-5$...	10·2 10·3	10·25	Orange tint.
7	7 58	115	$d+2$; $e-5$...	10·3 10·3	10·3	Slight orange tint.
13	7 58	115	$d+2$; $e-5$...	10·3 10·3	10·3	Slight orange tint.
Dec. 30	7 8	70 115	$=c$	9·8	9·8	

Mr. Knott's Diagram, Epoch 1880.

U Cygni.



Magnitudes of Comparison Stars:

	Knott.	Baxendell.		Knott.	Baxendell.
a	8·2	8·2	*f*	11·1	11·1
b	9·2	9·4	*g*	11·5	11·4
c	9·5	9·6	*h*	12·5?	
d	10·1	10·3	*z*	9·2	
e	10·4	10·5			

A star β (8·6) is also used by Mr. Knott from 1871 October 3; its position is R.A. 20^h 12^m 25^s, Decl. 47° 25′, which is thus outside the limits of the above diagram.

U Cygni.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astr. Journal*, No. 379).

No. 7299, *U Cygni*, R.A. for 1900·0 = $20^h\ 16^m\ 30^s$, Decl. = + 47° 34′·7.
Annual variations = + 1^s·86 and + 0′·19.
R.A. for 1855·0 = $20^h\ 15^m\ 7^s$, Decl. = + 47° 26′·3
Redness = 9·3. Max. mag. = 7·0 – 8·1. Min. = 9·4 – 11·6.
M – *m* = 229^d·0.
Maximum 1871 June 7 = 2404586^d (Julian).
Formula representing Period 463·5 E + 12 sin (36° E + 324°).

(From sixteen observations of max. and sixteen of min., including observations in 1871–94.)

Discovered by KNOTT, 1871. KNOTT thinks brightness at minimum is systematically variable. 8^m·5 foll. 5^s, 0′·7 N.

U Cygni.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1870. Oct. 15	h m 10 30	70	$a+8+10$; $c+0-?$; $=3073$ Arg.	9·0 9·2 9·5 9·5−, 9·3	9·3 ±	Mr. Birmingham's red star in Cygnus which will probably prove a variable. Obs. made between clouds. The star, which is a fine carmine red, is certainly not brighter than ninth mag.
17	9 0	70	$a+8+10$; $=$ Arg. $+47°$ 3067 (9·3)	9·0 9·2 9·3	9·2	Fine red.
24	10 40	70	3067+ ; $=c$; $a+10$	9·3+9·5 9·2	9·3	Fine carmine.
26	7 45	70	$a+10$ ...	9·2	9·2	Fine carmine red and about 9·3 mag.
1871. Jan. 5	8 10	70 89	$a+3$... ...	8·5	8·5	A splendid carmine. Very much brighter than in October 17, 1870.
12	7 4	70	$a+2+3$ ...	8·4 8·5	8·45	Fine red.
Feb. 6	7 15	70	$a+2$... ...	8·4	8·4	Orange red. 8·5 mag. est. 8h past meridian and cloudy.
Mar. 3	7 0	70	$a+0+1$ ...	8·2 8·3	8·25	Careful comparison. Fine red, but 9½h past meridian and among trees.
Apr. 4	10 55	70	$a-0-1$ ...	8·2 8·1	8·15	Fine red with orange cast. Certainly $>a$. So in finder.
May 17	11 50	70	$a-2\pm$ ...	8·0	8·0	8¼ est. Fine red. Its neighbour, a, decidedly bluish.
June 5	11 25	70	$a-2-3$ ...	8·0 7·9	7·95	Fine coppery red.
28	10 35	70	$a-2-3$ ...	8·0 7·9	7·95	Fine ruddy orange, and two tenths or so > its bluish neighbour a.
July 22	11 30	70	$a-1-2$ ...	8·1 8·0	8·05	Fine red orange, one or two tenths $>a$.
29	11 15	70	$a-1-2$ ...	8·1 8·0	8·05	Splendid carmine.
Aug. 15	11 57	70	$a-1$... ...	8·1	8·1	Beautiful colour. Clear carmine.
31	11 11	70 115	$=a$	8·2	8·2	The two stars about equal. The contrast of colours very marked, bluish white and fine carmine red.
Sept. 9	10 25	70 115	$=a$; $a+?$ ...	8·2 8·2+	8·2+	Fine carmine red, certainly not $>a$, perhaps slightly less. In finder decidedly less.
12	11 30	70	$=a$	8·2	8·2	Full coppery red.
20	10 15	70 115	$a+1+2$ ...	8·3 8·4	8·35	Fine clear carmine. Most decidedly $<a$.
Oct. 3	8 20	70	$a+3+4$; $\beta+0+1$ (β 8m·6)	8·5 8·6 8·6 8·7	8·6	Fine red. Among clouds. Decidedly less than when I observed it on September 20.
9	11 20	70	$a+3+4$ ...	8·5 8·6	8·55	Fine red. I do not think the star has changed much if at all since October 3.
12	11 40	70	$a+3$; $(=\beta)$	8·5 8·6	8·55	Beautiful carmine hue.
23	9 10	70 115	$a+5$; $\beta+2$...	8·7 8·8	8·75	Splendid colour. Clear carmine.
Nov. 18	7 25	70 115	$a+5$; $z-5$ $\beta+2$	8·7 8·7 8·8	8·7	Splendid clear carmine.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871. Nov. 29	h m 7 10	70	$a+5+6[z-4;$ $\beta+2+3]$	8·7 8·8 8·8 8·8 8·9	8·8	Fine carmine red. A most beautiful tint, $a=8·3$, β 8·6, z 9·3 est. z's neighbour 9·5 est.
Dec. 4	9 0	70 115	$a+10[=z]$ ...	9·2 9·2	9·2	U a splendid carmine, about ·1 mag. less than a. 9¼, 9½ est.
12	11 15	70	$a+10$; $=z$...	9 2 9·2	9·2	Fine red.
29	6 40	70 115	... ...	9·5 9·6 est.	9·55	Fine carmine. In mag. a few tenths less than the smaller of the components of z.
1872 Jan. 6	7 15	70 115	... ...	9·75	9·75	9¾ est., a fine brickdust red. Most marked colour.
Feb. 20	12 30	70	... ...	9¾ est.	9·75	Red. Less by some tenths than either component of z.
Mar. 5	11 15	70	About = lesser component of z	...	...	Fine carmine. Qu. Is it not brighter than when last observed? 10ʰ from meridian.
Apr. 13	11 20	70	$a+7$; $\beta+4$; $z-2$	8·9 9·0 9·0	9·0	Fine carmine red. 9 mag. est. Evidently past minimum.
May 15	11 15	70	$a+5+6$; $\beta+3$	8·7 8·8 8 9	8·8	Fine carmine.
21	11 10	70	$a+5$; $\beta+2$...	8·7 8·8	8 75	Splendid carmine.
June 13	11 15	70	$a+3$; $=\beta$ ...	8·5 8 6	8 55	Splendid clear carmine.
29	11 38	70	$a+1$; $\beta-2$...	8·3 8·4	8·35	Fine carmine tint.
July 9	11 15	70	$a+1$... ...	8·3	8·3	Fine red.
20	11 53	70	$=a$	8·2	8·2	Red, with orange cast. Perhaps a little less than a.
Aug. 28	10 25	70	$a-3$... ...	7 9	7·9	8·0 est. Fine coppery red. Some three-tenths > its bluish neighbour. About as much $>a$ as a is $>\beta$.
31	10 50	70	$a-3-4$ ...	7·9 7·8	7·85	Fine red with coppery cast.
Sept. 16	11 35	70	$a-5$... ...	7·7	7 7	U pale carmine red, with orange tinge. a pale blue. Both in finder and in large telescope U is some tenths brighter than a. Well seen in bright moonlight.
21	8 45	70	$a-4$... ...	7 8	7·8	Fine coppery red. a a delicate pale blue. Qu. Is U so much $>a$ as on the 16th?
Oct. 7	10 53	70	$a-2-3$ ...	8·0 7·9	7·95	Fine red. In finder the stars look equal. I fancy U must be past maximum.
22	9 10	70	$a-2$... ...	8 0	8·0	Fine red. In finder stars nearly equal. U rather $>a$.
28	10 30	70	$a-2$... ...	8·0	8·0	Fine red. Some 2-tenths brighter than its bluish neighbour.
Nov 7	8 28	70	$a-1$... ...	8·1	8·1	But little brighter than its bluish neighbour. I think, however, it is slightly the brighter of the two. Fine carmine, about 8¼ mag.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1872. Nov. 23	h m 8 25	70	$=a$	8·2	8·2	*U* fine red. *a* bluish. The stars equal as nearly as may be judged. *U not* $> a$.
Dec. 4	8 40	70	$=a$; $a+0·5+1$?	8·2 8·25 8·3	8·25	Fine fiery carmine red. Not brighter than *a*.
1873. Jan. 2	6 55	70	$a+2$... ...	8·4	8·4	Fine carmine red. Certainly less than *a*.
24	9 10	70	$a+3+4$ ...	8·5 8·6	8·55	Red.
28	6 40	70	$a+4+5$ ...	8·6 8·7	8·65	Fine carmine.
1876. Nov. 16	10 30	70	$a+4$... ...	8·6	8·6	Fine carmine colour. 8¾ est.
20	7 20	70	$a+5$... ...	8·7	8·7	Fine red.
29	8 30	70	$a+5$... ...	8·7	8·7	Fine red. 8¾ est.
Dec. 22	7 0	70	$a+7$... ...	8·9	8·9	Fine carmine. 9·0 est.
1877. Jan. 9	8 35	70	$a+20$ ...	10·2	10·2	10·3 est. Fine carmine.
25	8 30	70	$a+20$ ...	10·2	10·2	10·3 est. Fine red.
30	7 45	70	... ...	...	10·3 est.	Red. Decided colour.
Feb. 16	7 0	70	... ...	...	10·3 est.	Red.
Mar. 22	11 10	70	... ...	...	10·5 est.	Fine red. A fine colour. Very decided.
Apr. 26	11 40	70	... ...	9·5 9·7 est.	9·6	Fine red. 9½ ± est.
May 7	11 15	70	$a+7$... ...	8·9	8·9	Splendid carmine. 9 mag. est.
June 9	11 10	70	$a+5$... ...	8·7	8·7	Bright carmine. Bright 9 mag.
July 26	10 35	70	$a+1$... ...	8·3	8·3	Fine red. Clear sky.
Aug. 17	10 45	70	$a+1$... ...	8·3	8·3	Fine red. Clear colour.
Sept. 27	12 0	70	$a-2-3$ ...	8·0 7·9	7·95	Ruddy orange.
Nov. 14	8 5	70	$a-1$... ...	8·1	8·1	Fine ruddy orange. Slightly brighter than *a*.
22	8 40	70	$=a$	8·2	8·2	Fine red. *a* bluish.
1878. Jan. 30	10 30	70	$a+5$ ...	8·7	8·7	Decidedly red. A bright 9 mag. est. Nearly 11ʰ past meridn. and low, but sky pretty clear.
Feb. 6	8 20	70	$a+7$ ...	8·9	8·9	Ruddy. 9 mag. est.
Mar. 15	11 35	70	$a+7$ ...	8·9	8·9	Fine red. 9 mag. est.
May 21	11 0	70	... ...	...	10·3 est.	Fine red.
June 6	12 30	70	$a+22$; $g-10$	10·4 10·5	10·45	10·7 est. Red decidedly. *g* gauged 11·7.
12	11 30	70	... ...	10·5 10·7 est.	10·6	Fine red. Colour very decided.
25	12 25	115	... ...	10·5 est.	10·5	Very red.
July 13	11 40	...	... ...	10·5 est.	10·5	Fine red. A fine colour.
Aug. 1	11 30	70	... ...	9·7 est	9·7	Very fine red.
Oct. 12	10 30	115	$a+7+6$ ...	8·9 8·8	8·85	Red.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1878. Oct. 24	h m 8 0	70	$a+5$ ...	8·7	8·7	$8\frac{3}{4}$ est. Fine carmine colour.
Nov. 1	8 36	70	$a+4$ ...	8·6	8·6	Fine carmine.
7	9 0	70	$a+3$ ...	8·5	8·5	Fine carmine red.
1879. Feb. 12	7 30	70	$a-0-1$ ...	8·2 8·1	8·15	Fine red. *a* bluish.
24	7 15	70	$a+1+2$? ...	8·3 8·4	8·35	Fine red. In finder *U* decidedly $<a$. *a* bluish, 8·3 est.
Apr. 10	10 15	70	$a+5$? ...	8·7	8·7	Fine orange red. A bright 9 mag.
July 23	10 45	70	$a+22$; 11·7−12; 10·5 est.	10·4 10·5 10·5	10·5	Ruddy.
24	11 25	70	$=d$? ...	10·1	10·1 ?	Fine red. Clear. Gauged mag. of Mr. Baxendell's comp. stars for *U Cygni*. *a* 8·2; *b* 9·3; *c* 9·5; *d* 10·1 10·2; *e* 10·3 10·4; *g* 11·6 11·5.
Aug. 6	10 45	70	$=d$	10·1 ?	10·1 ?	Red.
11	10 30	70	$c+4+5$; $d-2-3$	9·9 10·0 9·9 9·8	9·9	Very red.
25	10 45	89 60	$e+0+2$; $g-8$	10·4 10·6 10·7	10·6	Very red. Clear sky, but high wind. Bad definition. With 60 power and *a* hidden by bar *U* abt. equal to *e*, perhaps hardly equal. *e* 10·5, *g* 11·5 est.
30	8 30	60	$d+3$; $=e$ ...	10·4 10·4	10·4	Very red. *a* hidden by bar. *d* 10·2, *e* 10·5 est. Clear. Bright moon near full. $U=c+10$ $g-10$.
Sept. 1	10 40	89	... ...	10·5	10·5	With full aperture; very red, $=e+0+1$. With 4-in. aperture decidedly less than *e*, and more nearly $=f$. Moonlight. Clear. With full aperture $U=e+0+1$, say. With 4-in. aperture $U=e+4$ $f-2$ say *e* 10·5 est. *f* 11·1, *g* vis. well with 3-in. aperture = 11·5, star below *g* with 4-in. glimpsed. = 12·5.
Oct. 3	10 40	115	$e+5$; $=f$; $g-5$	10·9 11·1 11·0	11·0	Very red. Careful estimates. With 4-in. aperture, more nearly $=g$.
6	9 5	115	$e+5$; $=f$; $g-5$	10·9 11·1 11·0	11·0	Very red. Careful estimates. Full aperture. Obs. checked by throwing stars out of focus.
11	8 30	89	$\frac{1}{2}(e+g)$; $=f$...	11·0 11·1	11·05	Fine red, with full aperture and ap. of 4-in. mag. est. as given. Abt. 11 mag. est.
15	11 5	70	$f-0-1$ ...	11·1 11·0	11·05	Fine red.
Nov. 5	7 45	70	$c+6$; $=d$; $e-3$	10·1 10·1 10·1	10·1	Fine red. Careful scrutiny checked by putting stars slightly out of focus. I do not think I have *over-estimated U*.
12	8 45	70	$c+5$; $d-1$...	10·0 10·0	10·0	Very fine red. Cold N.W. wind.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1879. Dec. 1	h m 10 20	...	$a+5$; $b-5$; $c-7$	8·7 8·7 8·8	8·7	Fine red. *a* bluish tint.
6	8 25	70	$a+7$; $b-4$...	8·9 8·8	8·85	Very fine red.
16	8 30	70	$a+5$; $b-5$...	8·7 8·7	8·7	Fine red. A fine colour.
26	7 20	70	$a+3$; $b-7$...	8·5 8·5	8·5	A fine red. About equal star rather more than halfway from *U* to 32? *Cygni*.
1880. Jan. 2	8 0	70	$a+3$; $b-7$...	8·5 8·5	8·5	Fine red.
31	8 50	70	$a+3$ ...	8·5	8·5	Fine red.
Apr. 1	10 35	70	$a-3$ ...	7·9	7·9	Fine red. *a* bluish.
20	10 40	70	$a-3-4$ ...	7·9 7·8	7·85	Splendid red. *a* blue.
May 17	10 35	70	$a-2$ ...	8·0	8·0	Fine orange red. *a* blue.
June 7	10 50	70	$=a$	8·2	8·2	Fine ruddy hue. *a* pale blue.
25	11 0	70	$=a$; $a+1$??	8·2 8·3?	8·25	Fine red. *a* pale blue. *U* barely $=a$.
July 29	11 30	70	$a+4$ ...	8·6	8·6	Fine red.
Aug. 10	10 55	70	$a+4+5$ ...	8·6 8·7	8·65	Fine red. *a* blue.
31	8 30	70	$a+7$; $b-3$...	8·9 8·9	8·9	Orange red.
Sept. 29	9 0	70	$c+1$; $d-5$...	9·6 9·6	9·6	Fine red.
Oct. 18	7 55	70	$=c$; $a+13$; $d-6$	9·5 9·5 9·5	9·5	Fine red.
Nov. 8	9 0	115	$=g$	11·5	11·5	Ruddy decidedly.
Dec. 30	7 40	70 115	$f+2$; $g-2$ ...	11·3 11·3	11·3	Decidedly red.
1881. Feb. 10	6 30	70	$c+2$; $d-4$ ...	9·7 9·7	9·7	Decided red. Among clouds. Moonlight. Doubtful observn.
Mar. 15	10 35	115	... ...	9·2	9·2	10th from meridn. and haze troublesome. *b* and *c* seen and the two components of *z*.
29	13 7	70 115	$=c$	9·5	9·5	Fine carmine red.
May 20	11 20	70	$a+4$; $c-9$...	8·6 8·6	8·6	Fine carmine.
30	9 50	70	$a+4$; $c-9$...	8·6 8·6	8·6	Fine orange red.
Aug. 2	10 30	70	$a-2$ ...	8·0	8·0	Orange red.
6	10 20	70	$=a$	8·2	8·2	Fine orange red, $=a$. So too in finder (2-in. aperture).
Sept. 26	8 45	70	$a+3?+5?$ In finder $a+5$	8·5 8·7 8·7	8·7	Fine fiery red. (*U* in finder so decidedly less than *a* that I think its mag. must be about 8·7).
28	8 55	70	$a+4+5$ ...	8·6 8·7	8·65	Fine red. Fiery red.
Oct. 4	8 55	70	$a+4$; $b-6$...	8·6 8·6	8·6	Fine fiery red. Clear sky. Moonlight. In telescope, and obs. checked in finder.
15	8 25	70	$a+5$; $b-5$...	8·7 8·7	8·7	Fine colour. Flame red.
19	7 35	70	$a+4$? ...	8·6	8·6	Fine orange red.
Nov. 15	8 35	70	$a+8$; $b-2$...	9·0 9·0	9·0	Orange red. Fine tint.
17	8 40	...	$a+8$; $b-2$...	9·0 9·0	9·0	Splendid red.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881.	h m					
Dec. 3	7 37	70	$a+10$; $=b$...	9·2 9·2	9·2	Orange red. Among clouds; and moonlight.
8	7 32	115	$a+10$; $f-9$; $c-3$	9·2 9·2 9·2	9·2	Fine red. A fine colour.
23	8 23	115	$d+1+2$; $e-1-2$	10·2 10·3 10·3 10·2	10·25	
1882.						
Jan. 7	6 53	115	$=f$	11·1	11·1	With 3-in. aperture $=f$. With full aperture brighter. Fine red.
Mar. 16	8 15	115	$=g$? $g+$? ...	11·5 11·7	11·6	$11\frac{1}{2}^{h}$ past meridian.
Apr. 20	10 50	115	$e+7$; $g-4$; $=f$	11·1 11·1 11·1	11·1	Fine red.
May 18	11 16	70	$=d$; $d-1$ ...	10·1 10·0	10·05	Very red.
June 15	10 55	70	$=c$; $c-1$ ...	9·5 9·4	9·45	Splendid red.
July 24	10 25	70	$=b$?... ...	9·2?	9·2	9·0 9·2. Fine red.
Aug. 3	10 30	70	$a+7$; $b-3$...	8·9 8·9	8·9	Fine red.
Oct. 2	8 45	70	$a-2$... ...	8·0	8·0	Fine red. Both in large telescope and in finder certainly brighter than a.
23	8 25	89	$a-3$... ...	7·9	7·9	Decidedly brighter than a in finder as well as in large telescope. Fine red.
Nov. 17	7 42	70	$a-2$... ...	8·0	8·0	Fine orange red.
28	8 20	70	$a-2$... ...	8·0	8·0	Fine red. 8·0 gauged.
Dec. 19	8 40	70	$a-1$... ...	8·1	8·1	Certainly a little brighter than a. Fine red. Slightly the brighter too in finder.
1883.						
Feb. 6	8 0	70	$a+2+3$ ...	8·4 8·5	8·45	Fine red with orange tint. Certainly less than a. Tried with finder and with 3·2 aperture in the telescope.
22	7 30	70	$a+6$; $b-4$...	8·8 8·8	8·8	Fine red. With full aperture the difference between a and U seems hardly so large. But in finder (2-inch) and with aperture of telescope reduced to $2\frac{1}{4}$ inch the difference is as given.
May 7	10 25	70 110	$e+4$; $f-3$ ...	10·8 10·8	10·8	Fine red. Mag. estimated with aperture reduced to 3·2 inch. With full aperture U brighter considerably. Fine clear red.
31	11 15	110	$f+3$; $g-1$ ...	11·4 11·4	11·4	Red. Obsd. with 3-inch aperture in telescope.
June 30	11 0	115	$g-1-2$ ...	11·4 11·3	11·35	
July 28	10 27	70	$e+2$... ...	10·6	10·6	Fine red.
Aug. 24	9 0	70	$c+5$; $d-1$...	10·0 10·0	10·0	Fine red.
Oct. 2	8 5	70	$c+1+2$; $d-4-5$	9·6 9·7 9·7 9·6	9·65	Fine red. A fine tint.
4	8 7	70	$c-1$; $b+2$...	9·4 9·4	9·4	Splendid red. Clear but high wind from north. Finder and telescope. U certainly not less than c.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1883 Oct. 20	h m 8 25	70	$a+7$; $c-6-5$	8·9 8·9 9·0	8·9	Fine red. About 9 mag. Obs. difficult from intensity of colour.
Nov. 10	7 58	70	$a+4$... ...	8·6	8·6	Fine orange red.
26	8 15	70	$=a$	8·2	8·2	Splendid red. Careful obs. in telescope and finder (2-inch).
Dec. 21	7 50	70	$=a$ ($a+$??)...	8·2 (8·25??)	8·2	Fine orange red.
1884. Jan. 12	7 48	70	$a-3-4$ ...	7·9 7·8	7·85	So in finder and with aperture of telescope reduced to 3 inches. Very fine orange red, and very decidedly brighter than *a*.
19	7 50	70	$a-3-4$ ...	7·9 7·8	7·85	So in finder and in telescope with aperture reduced to 2¼ inch. Orange red. Decidedly brighter than *a*.
Feb. 11	8 20	70	$a-4-5$ ...	7·8 7·7	7·75	Fine orange red. Very decidedly brighter than *a* in telescope and in finder.
29	8 0	70	$a-2$... ...	8·0	8·0	Fine orange red. Brighter than *a*. So too in finder.
Apr. 16	9 10	70	$a+4$? ...	8·6	8·6	Ruddy. About 8½ mag.
June 30	11 45	70	$a+10$; $c-3$	9·2 9·2	9·2	Fine red. 3·2-inch aperture.
July 7	11 0	70	$a+10$; $=b$; $c-5$	9·2 9·2 9·0	9·2	Carmine red. Fine colour.
17	10 48	70	$=c$	9·5	9·5	Carmine red.
Aug. 1	10 28	70	$c+3$; $d-3$...	9·8 9·8	9·8	Fine carmine red.
22	8 40	70	$d+2$; $e-1$...	10·3 10·3	10·3	Fine red. 3-inch aperture.
Oct. 4	10 15	70	$e+3$; $f-4$...	10·7 10·7	10·7	Very fine red.
13	10 10	110	$g-2$; $f+2$...	11·3 11·3	11·3	11¼ 11½ est.
24	8 40	70 115	$=g$	11·5	11·5	11·5 11·6 gauged. Very red.
29	8 35	70	$e+6$; $f-1$; $g-5$	11·0 11·0 11·0	11·0	Full carmine red. A fine colour. 3·7-inch aperture.
Nov. 7	9 10	70	$e+2$; $f-5$...	10·6 10·6	10·6	Fine red. Obs. difficult. 3·7-inch aperture. The full colour of *U* makes comparison difficult.
15	9 0	115	$e+0$... ...	10·4	10·4	3·7-inch aperture.
22	8 55	70	$d-2$; $c+4$...	9·9 9·9	9·9	Fine carmine red.
28	8 40	70	$c+3$; $d-3$...	9·8 9·8	9·8	Fine carmine.
Dec. 4	8 25	70	$=c$	9·5	9·5	Full red.
9	8 45	70	$c-3$; $=z$ ...	9·2 9·2	9·2	Carmine red.
1885. Jan. 6	8 57	70	$a+7$; $b-3$...	8·9 8·9	8·9	Very fine red.
Feb. 5	7 36	70	$a+2$... ...	8·4	8·4	Fine carmine. Less than *a* by about 0·2 in finder also.
Apr. 18	11 0	70	$a-4$... ...	7·8	7·8	Fine red.
May 11	11 0	110	$a-5-6$ ...	7·7 7·6	7·65	Fine red. *b* very decided blue.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885.	h m					
May 29	10 5	70	$a-4-5$ ...	7·8 7·7	7·75	7·8 gauged. Ruddy orange. *a* bluish. Moon rising.
June 17	10 40	70	$a-3-4$ ...	7·9 7·8	7·85	*a* very fine pale blue. *U* fine red with orange tinge.
July 10	11 45	70	$a-3$... ...	7·9	7·9	Fine red. *a* bluish. *U* decidedly the brighter both in finder and in telescope.
23	10 30	70	$a-1-2$ ...	8·1 8·0	8·05	Fine red in contrast with the decided blue of *a*. Bright moonlight. Sky clear.
Aug. 10	11 52	70	$=a$	8·2	8·2	In telescope and in finder *U* and *a* as nearly equal as possible, perhaps *U* slightly the brighter. *U* red orange. *a* pale blue.
29	9 5	70	$=a$? $a+1$?...	8·2 8·3	8·25?	Very red. *a* pale blue. Possibly *U* rather the less of the two.
Oct. 7	8 5	70	$a+5$; $b-5$...	8·7 8·7	8·7	Fine red. Obs. confirmed in finder.
Nov. 17	7 55	70	$c+2$; $d-4$...	9·7 9·7	9·7	Fine red.
Dec. 10	6 40	70	$=c\pm$ ...	9·5 ±	9·5 ±	Fine full red.
1886.						
June 1	10 58	70	$=a$	8·2	8·2	*U* fine red. *a* pale blue. $U=a$ in finder and in telescope.
23	10 32	70	$a-1$... ...	8·1	8·1	Orange red. More red than *T Cephei*. In finder nearly equal *a*, slightly brighter?
July 24	10 55	70	$a-3$... ...	7·9	7·9	Red; fine colour. *a* blue.
Aug. 10	10 0	70	$a-2-3$ ...	8·0 7·9	7·95	*U* orange red, fine tint. *a* pale blue, fine tint. Both in telescope and in finder *U* decidedly, by two or three tenths, brighter than *a*.
Sept. 30	9 5	70	$a-2-3$ ...	8·0 7·9	7·95	Fine carmine red. *a* clear pale blue.
Oct. 21	8 22	70	$=a$?... ...	8·2	8·2	Fine red. *a* bluish. In finder the stars about equal.
Nov. 16	7 30	70	$a-1$... ...	8·1	8·1	*a* pale blue. *U* fine red. In finder $U=a-1-0$.
29	8 30	70 115	$=a$	8·2	8·2	Clear red. *a* bluish.
Dec. 14	8 40	70	$a+2$... ...	8·4	8·4	*a* pale blue. *U* red with orange tinge.
30	8 0	70	$a+2$? ...	8·4	8·4	Orange red. *a* bluish white. Hazy. Observation doubtful.
1887.						
Jan. 25	7 0	70	$a+5$; $c-8$...	8·7 8·7	8·7	(Qu. *b* var.? $c+1$ 9·6.) *U* ruddy orange.
Feb. 1	6 50	70	$a+5$; $b-5$...	8·7 8·7	8·7	Orange red. $b=c-3$ (∴ 9·2 mag.).
12	8 0	70	$a+10$; $=b$; $c-3$	9·2	9·2	Orange red. Full colour. Obs. a little difficult and doubtful.
Mar. 1	8 25	70	$a+10=b\,(b-)$	9·2	9·2	About $9\frac{1}{4}$ est. $10\frac{3}{4}$ hrs. past meridian.
Apr. 8	10 10	70 115	$c+5$; $d-1$...	10·0 10·0	10·0	Very red. 9h from merid. Moonlight and a high wind. Bad definition. Full and 4-in. aperture.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887.	h m					
Apr. 30	10 43		$c+5$; $d-1$...	10·0 10·0	10·0	Full red.
May 10	11 20	115	$d+1$; $e-1$...	10·2 10·2	10·2	Red.
20	10 43	115	$e+2$; $f-5$ ...	10·6 10·6	10·6	Red.
June 13	10 50	115	$=e$? $e+$? ...	10·4	10·4	Very red. Observation difficult.
30	11 10	70 115	$c+2$; $d-4$...	9·7 9·7	9 7	Full red. 3·2 in. aperture on telescope.
July 18	10 30	70	$a+6$; $b-4$...	8·8 8·8	8·8	Very red.
Aug. 12	10 35	70	$a+1+2$ ...	8·3 8·4	8·35	Fine red.
Oct. 17	8 30	70	$a-3$... ...	7·9	7·9	Orange red. 7·9 gauged.
31	8 35	70	$a-4$... ...	7·8	7·8	Orange red, full colour. Gauged 7·8
Nov. 14	8 25	70	$a-4$... ...	7·8	7·8	Orange ruddy. *a* bluish.
30	7 45	70	$a-4$... ...	7·8	7·8	Fine orange red.
1888.						
Jan. 10	7 30	70	$a-4$... ...	7·8	7·8	Fine orange red. *a* decided pale blue.
Mar. 5	7 5	70	$=a$	8·2	8·2	Orange red.
21	8 7	70	$a+2$... ...	8·4	8·4	Ruddy. 12 hrs. past meridian.
Apr. 26	10 45	70	$a+4$... ...	8·6	8·6	Full red.
May 25	10 30	70	$a+7$; $b-3$...	8 9 8·9	8·9	Full orange red.
June 6	11 0	70	$d+1$; $e-2$...	10·2 10·2	10·2	Haze coming over. Ruddy.
Aug. 3	11 10	70 115	$d+1$; $e-2$...	10·2 10·2	10·2	Red.
13	8 55	70 115	$e-1$; $d+2$...	10·3 10·3	10·3	Very red.
Oct. 5	8 25	70	$a+10$; $=b$; $c-3$	9·2 9·2 9·2	9·2	Very red. About $9\frac{1}{4}$ est.
13	8 40	70	$a+5$; $b-5$...	8·7 8·7	8·7	Very red.
23	8 30	70	$a+3+4$ ...	8·5 8·6	8·55	Fine red.
Nov. 3	8 57		$a+1$... ...	8·3	8·3	*U* very red. *a* pale blue. Observed in telescope and in finder. In telescope *U* and *a* very nearly equal.
13	8 0	70	$a+3$... ...	8·5	8·5	Red, decidedly less than *a*. Observed in telescope and in finder.
20	7 40	70	$a+1$... ...	8·3	8·3	Fine red.
28	8 5	70	$a+2$... ...	8·4	8·4	In finder $a+2$, fiery red. *a* gauged 8·2 bluish.
Dec. 6	7 40	70	$a+2$... ...	8·4	8·4	Red. *a* bluish. In telescope and in finder.
10	7 20	70	$a+1$... ...	8·3	8·3	Orange red. *a* bluish.
26	7 20	70	$a+2$... ...	8·4	8·4	Very red. Certainly not so bright as *a* either in telescope or finder.
1889.						
Jan. 27	8 25	70	$a+0+1+2$...	;	8·3	Equal in telescope, barely equal in finder. Stars a little low. *U* full red.
Feb. 4	8 40	70	$a-1$... ...	8·1	8·1	Very red. *a* bluish. *U* rather brighter than *a* in finder too. Stars low, 9^h 20^m past meridian.
Mar. 6	8 43	70	$a-2$... ...	8·0	8·0	$11\frac{1}{2}^h$ past meridian. Low. Obs. difficult.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889	h m					
Apr. 15	8 50	70	$=a$? ...	8·2?	8·2?	Fine clear red. Not less than *a*, I think. 2·7 aperture in telescope. Hazy sky illumined by Moon.
June 3	10 37	70	$a+1+2$ ...	8·3 8·4	8·35	
Aug. 7	9 53	70	$a+5$... ...	8·7	8·7	Orange red.
Sept. 6	9 0	70	$a+9$; $b-1$...	9·1 9·1	9·1	Fine red.
10	8 33	70	$a+8$; $b-2$ ..	9·0 9·0	9·0	Carmine red.
Oct. 21	8 40	70	$e-4$; $d-1$; $c+5$	10·0 10·0 10·0	10·0	Red. Difficult to observe from colours.
25	8 5	70 115	$=d$; $e-3$ ...	10·1 10·1	10·1	Very red.
31	7 30	115	$d+1$; $e-2$...	10·2 10·2	10·2	Red.
Nov. 12	7 40	115	$d+2$; $e-1$...	10·3 10·3	10·3	Full carmine red. A splendid colour.
25	8 6	70 115	$d+2$; $e-1$...	10·3 10·3	10·3	Carmine red.
30	8 23	70 115	$=d$; $e-3$ ...	10·1 10·1	10·1	Fine red. Slight orange tint.
Dec. 4	8 10	70 115	$d-0-1$; $e-3-4$	10·1 10·0 10·1 10·0	10·05	Red, with very slight orange tinge.
11	7 57	70 115	$=d$; $c+6$ ...	10·1 10·1	10·1	Red with orange tinge. Hazy sky.
24	8 0	70	$c+3$; $d-3$...	9·8 9·8	9·8	Orange red.
1890.						
Mar. 12	7 55	70	$a+4+5$ ...	8·6 8·7	8·65	11 hrs. past meridian. Confused vision.
Apr. 1	10 3	70	$a+2$... ...	8·4	8·4	Fine red with orange cast.
22	10 43	70	$a-2$... ...	8·0	8·0	Fine red. *a* blue tint.
June 9	11 0	70	$a-4$... ...	7·8	7·8	Orange red.
Aug. 1	10 32	70	$=a$	8·2	8·2	So, too, in finder. *a* pale blue. *U* full red.
18	9 54	70	$a+1$... ...	8·3	8·3	Full red. *a* bluish.
23	10 8	70	$=a$	8·2	8·2	*U* full red. *a* pale blue.
Sept. 8	10 53	70	$=a$	8·2	8·2	So also in finder. *a* bluish white. *U* very red.
Oct. 25	8 0	70	$a+5$; $z-5$...	8·7 8·7	8·7	Carmine red.
Nov. 4	7 57	70	$=z$	9·2	9·2	Red.
9	8 0	70	$z+1$; $c-2$; $a+10$	9·3 9·3 9·2	9·3	Carmine red. Clear and deep.
13	8 22	70	$c+3$; $d-3$...	9·8 9·8	9·8	3·7 in. aperture in telescope. Carmine red.
28	7 10	70	$=d$; $e-3$ ...	10·1 10·1	10·1	Red.
Dec. 1	7 2	70 115	$d+2$; $f-8$...	10·3 10·3	10·3	Clear red with slight orange tinge. *e* fainter than 10·4? = 10·7?
9	6 37	70	$d+1$; $e-2$...	10·2 10·2	10·2	Carmine red. *e* 10·4 mag.
12	8 17	70 115	$d+2+3$; $e-0-1$	10·3 10·4 10·4 10·3	10·35	Pale carmine red. Clear colour.
22	8 45	70	$d+1$; $e-2$...	10·2 10·2	10·2	Carmine red. Observed with full aperture and one of 3·2 inches.
1891.						
Jan. 1	6 35	70 115	$d+2$; $e-1$...	10·3 10·3	10·3	Carmine red.

U Cygni—continued.

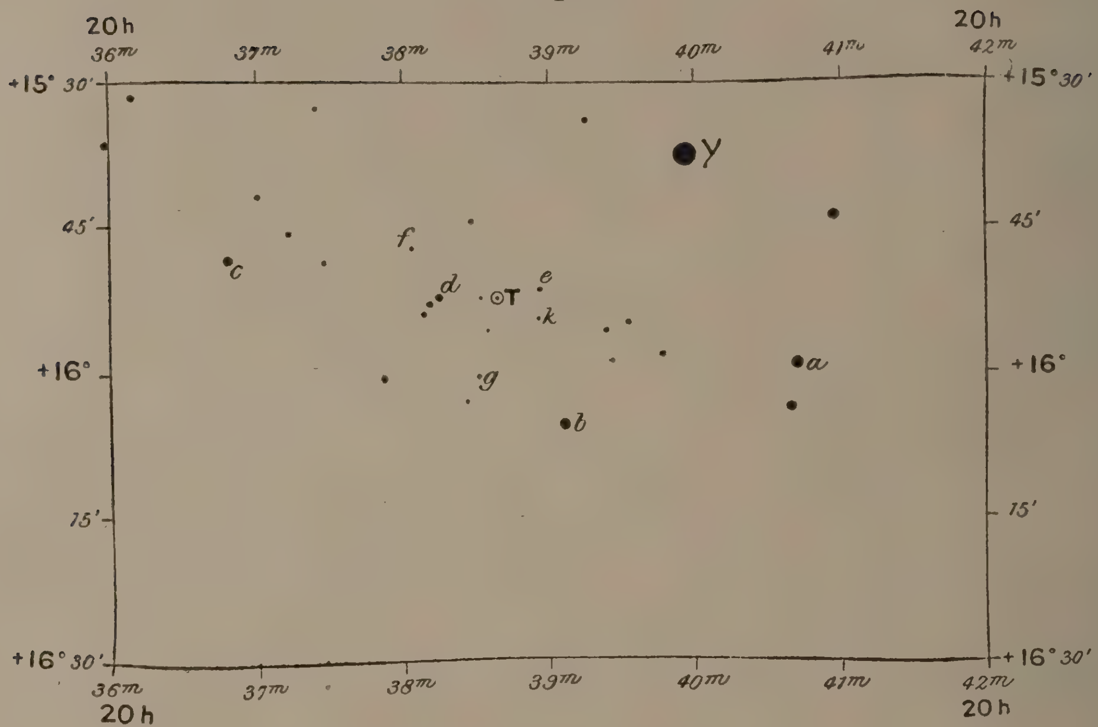
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1891.	h m					
Jan. 21	6 45	70 115	$=e$	10·4	10·4	Carmine red.
Feb. 1	6 35	70 115	$f+1$; $g-4$...	11·2 11·1	11·15	Red.
4	7 30	115	$e+6$; $g-5=f$	11·0 11·0 11·1	11·0	Red. Rather low.
10	7 35	115	$f+2$; $g-2$...	11·3 11·3	11·3	Red. Stars rather low. Obs. a little doubtful.
19	7 5	115	$f+2$; $g-2$...	11·3 11·3	11·3	Bright moonlight, and stars far from meridian.
25	7 4	115	$=f$; $g-4$; $e+7$	11·1 11·1 11·1	11·1	Red. Stars low. Obs. difficult.
Mar. 26	7 45	115	$d+1$; $e-2$...	10·2 10·2	10·2	11·45^h past meridian. Obs. difficult.
Apr. 6	10 31	70	$c+3$; $d-3$...	9·8 9·8	9·8	Carmine red. Fine tint.
26	10 30	70 115	$c+2+1$; $d-4-5$	9·7 9·6 9·7 9·6	9·65	Carmine red.
June 5	10 26	70	$a+2+3$ ...	8·4 8·5	8·45	Red. *a* white with slight blue tint.
July 28	10 50	70	$=a$	8·2	8·2	
Aug. 10	10 30	70	$=a$	8·2	8·2	Red. *a* pale blue.
Sept. 4	8 45	70	$a-1-2$ ...	8·1 8·0	8·05	Clouds coming over.
Oct. 12	8 57	70	$a-3$... ...	7·9	7·9	*U* red. *a* bluish.
28	8 10	70	$a-2$... ...	8·0	8·0	In large telescope and in finder. *U* very red. *a* pale blue.
Nov. 3	8 30	70	$=a$	8·2	8·2	*a* bluish. *U* red with slight orange tinge.
5	8 31	70	$a-1$... ...	8·1	8·1	*U* red with orange cast. *a* bluish white.
Dec. 17	6 38	70	$a+2$... ...	8·4	8·4	Carmine red. Not quite so fine a tint as *V Cygni*.
1892.						
Jan. 4	8 15	70	$a+5$... ...	8·7	8·7	Carmine red. Not so deep in tint as *V*.
15	7 15	70	$a+5$; $b-5$...	8·7 8·7	8·7	Red.
24	7 14	70 115	$a+11$; $z+1$; $c-2$	9·3 9·3 9·3	9·3	Very red.
Feb. 2	8 18	70	$c+2$; $d-4$...	9·7 9·7	9·7	Carmine red.
22	7 5	115	$d+2$; $e-1$...	10·3 10·3	10·3	Red with orange tint.
27	7 38	115	$\frac{1}{2}(d+e)$ ...	10·25	10·25	Red.
Mar. 19	7 53	115	$=e$	10·4	10·4	Doubtful obs. 11½^h past meridian.
Apr. 19	10 43	115	$e+4$; $f-3$...	10·8 10·8	10·8	Red.
May 21	10 15	70 115	$e+7$; $=f$; $g-4$	11·1 11·1 11·1	11·1	Fine red.
30	10 35	70	$e+6$; $f-1$...	11·0 11·0	11·0	Carmine red.
July 10	11 5	70	$=d$; $c+6$ ...	10·1 10·1	10·1	Carmine red. Full of colour.
28	11 2	70	$c+3$; $d-3$...	9·8 9·8	9·8	Carmine red. Brilliant tint.
Sept. 24	8 40	70	$=c$	9·5	9·5	Abt. $=c$ in finder. Very red.
Oct. 11	9 0	70	$=c$?... ...	9·5?	9·5?	Very red. Obs. doubtful.

U Cygni—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1892. Oct. 11	h m 10 0	70	$=z$	9·2	9·2	Very red. I now think it is certainly $>c$, and in telescope and finder about $=z$ ∴ 9·2.
20	8 15	70	$z-2$... ...	9·0	9·0	Very red. About 9·0 est.
Nov. 3	8 53	70	$a+1$... ...	8·3	8·3	Carmine red.
18	8 20	70	$a+2$... ...	8·4	8·4	Very red.
26	8 59	70	$=a$	8·2	8·2	Very red. Equal *a* in finder too.
30	8 6	70	$a-1$... ...	8·1	8·1	Very red. Fine tint. *a* pale blue. $U>a$ both in telescope and in finder.
Dec. 12	7 21	70	$a-1$... ...	8·1	8·1	Fine red. *a* pale blue.
1893. Jan. 15	7 0	70	$a-2$... ...	8·0	8·0	Very red.
Feb. 7	7 45	70	$a+2$... ...	8·4	8·4	Very red. Low. Hazy sky.
Mar. 31	9 5	70	$a+4+5$ ...	8·6 8·7	8·65	$13\frac{1}{2}^{h}$ past meridian. Very red. 4-in. aperture.
May 6	10 0	70	$c+2$; $d-4$...	9·7 9·7	9·7	Carmine red.
June 30	10 11	70	$e+6$; $f-1$...	11·0 11·0	11·0	Carmine red. Full of colour.
Aug. 4	10 35	115	$f+1$; $g-3$...	11·2 11·2	11·2	Carmine red.
Sept. 30	8 28	70	$d+3$; $=e$ ...	10·4 10·4	10·4	Very red.
Oct. 12	7 50	70	$d+2$; $e-1$...	10·3 10·3	10·3	Carmine red.
19	7 59	70 115	$d+1$; $e-2$...	10·2 10·2	10·2	Carmine red.
27	7 19	70	$d-1$... ...	10·0	10·0	Red.
Nov. 6	8 50	70	$=d$	10·1	10·1	Carmine red.
13	8 35	70	$=c$	9·5	9·5	Very red; well seen in finder. Rather brighter than *c* ?
Dec. 2	8 28	70	$z+1$; $c-2$...	9·3 9·3	9·3	Full carmine red.

Mr. KNOTT'S Diagram, Epoch 1855·0

T Delphini.



Approximate magnitudes of Comparison Stars :

a	8·2	*f*	...
b	8·5	*g*	11·2
c	9·0	*h*	...
d	9·7	*k*	12·2

e 10·8 variable to extent of some few tenths.

In one or two of the earlier observations the magnitudes of *d* and *e* are assumed 9·4 (or 9·5) and 10·3 (or 10·4) respectively, in the original MS. But as from 1866 the above magnitudes were adopted uniformly by Mr. KNOTT, the early observations have been corrected.

T Delphini.

The following particulars are given in Chandler's "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379):

No. 7444 *T Delphini*, R.A. for 1890·0=$20^h\ 40^m\ 43^s$, Decl.=$+16°\ 2'·1$.
Annual Variation =$+2^s·78$ and $+0'·22$.
R.A. for 1855·0=$20^h\ 38^m\ 38^s$, Decl.=$+15°\ 52'·5$.
Redness=2·0. Max. magnit. 8·2–10·3. Min. < 13.
Maximum, 1864 September 16=2402133^d (Julian).
Period $331^d·2$.
(From seventeen observations of max., including observations in 1855–93.)

Discovered by Baxendell, 1863. Possibly a secondary maximum near principal one. Decrease unusually rapid. 11^m preceding 3^s, $2'·7$ N.; $10^m·1$ foll. 12^s, $0'·1$ N.

[The star was observed by Mr. Knott under the designation *S Delphini.*]

T Delphini.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863. Oct. 29·3	h m	60	½ (*b*+*c*) ...	8·75	8·75	
Nov. 11		...	*b*+4+5; =*c*; *c*−1?	8·9 9·0 9·0 8·9	8·95	Est. = star preceding on parallel (rej.)
Dec. 3		60	[✱ prec. on parallel (*d*) or ✱−1]	[9·7 9·6]	...	Rej.
9		60	*c*−1; *d*−6−7	9·1 9·1 9·0	9·1	Very clear.
1864. Aug. 6·3		60?	:... ...	11 ± est.	11 ± est.	
Sept. 24·3		60	=*b*	8·5	8·5	
26·3		60	*b*+1+2 ...	8·6 8·7	8·65	Gauged 8·2 8·3. *T* slightly ruddy.
27·3		60	*b*+3; *c*−2...	8·8 8·8	8·8	
29·3		60	*b*+4; *c*+1?	8·9 9·1	9·0	Decidedly ruddy. *b*=*a*?
Oct. 3·3		60	*b*+3? ...	8·8	8·8	*b*=*a*+1?
Nov. 4·3		60	*e*+4+5 ...	11·2 11·3	11·25	Is *e* so bright as 10·1? but past meridian and not clear. (See note on p. 258.)
5·3		60	*e*+3+2 ...	11·1 11·0	11·15	
22·3		60	... ...	11·3 est.	11·3 est.	*e* gauged 10·3 10·4 mag.
26·3		60 102	... ...	12·1 gauged	12·1	*e* gauged 10·6 mag.
Dec. 1·3		...	... ...	13·0 est.	13·0 est.	
1865. Apr. 29·5		60	Not seen ...	Under 13	< 13	
May 15·3		60	Not seen ...	Under 12	< 12	
22·5		60 102	Not seen ...	Under 13	< 13	Star *f* about 10·8 mag.
24·5		60 102	Not seen ...	Under 12·5	< 12·5	*e*=10·7.
31·4		60	Not seen ...	Under 13·5	< 13·5	
June 19·5		...	... ...	13 ±	13 ±	A faint object. Hazy?
27·5		102	*k*+2... ...	12·4	12·4	12·5 est.
July 3		60	*k*−1... ...	12·1	12·1	
11·4		60	*e*+3; *g*−1...	11·1? 11·1	11·1	
19·4		60	*d*+4; *e*−5...	10·1 10·3	10·2	Gauged comp. stars, *a* 8, *b* 8·5, *c* 9·0, *d* 9·5 9·4, *e* 10·4 10·3, *g* 11·3, *h* 11·7, *k* 12·1 12·2.
25·4		...	*d*−0−1 ...	9·7 9·6	9·65	
26·4		60	*c*+2; *d*−1...	9·2 9·6	9·4	Ruddy.
28·5		60	*c*+2+3; *b*+7	9·2 9·3 9·2	9·2	*c*=9·0 est, *d* 9·4, *e* 10·4 gauged.
Aug. 1·4		60	*c*+2+3; *d*−1−2	9·2 9·3 9·6 9·5	9·4	*e* 10·3.
5·5		60	*b*+2; *c*−3...	8·7 8·7	8·7	Ruddy. *e* 10·3 est.
9·4		60	*b*+3; *c*−2...	8·8 8·8	8·8	Ruddy. Moonlight.
14·4		60	*b*+5; =*c*; *d*−3−4	9·0 9·0 9·4 9·3	9·2	*T* ruddy.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865.	h m					
Aug. 18·4		60	$b+4$; $c-1$ ...	8·9 8·9	8·9	Ruddy. *e* 10·4 est.
22·4		...	$b+5$; $=c$; $d-3$	9·0 9·0 9·4	9·1	Ruddy slightly. $d=9·4$ est.
24·5		60	$d-3$; $c+1$; $b+6$	9·4 9·1 9·1	9·2	Very decidedly ruddy.
30·4		60	$c+3$; $d-1-2$	9·3 9·6 9·5	9·5	Ruddy. [*d* 9·4.]
Sept. 4·4		60	$d-1$ ...	9·6	9·6	Ruddy. Decidedly < *c*. [$d=9·4$.]
7·4		60	$d-1$ ...	9·6	9·6	[$d=9·4$.]
12·3		60	$=d$	9·7	9·7	*d* 9·4 9·5.
14·3		60	$d+2$ ...	9·9	9·9	
18·3		60	$d+3+4$; $e-6$	10·0 10·1 10·2	10·1	$d=9·5$ 9·6, $e=10·4$ (gauged).
20·4		60	$d+4+5$; $e-3$	10·1 10·2 10·5	10·3	
Oct. 3·4		60	$e+2$; $g-7$...	11·0 10·5	10·75	
4·5		70	$e+2$; $g-7$...	11·0 10·5	10·75	$e=10·4$ est.
5·3		70	$e+1$... ...	10·9	10·9	
13·3		70	$g+0+1$ ...	11·2 11·3	11·25	
20·3		70	$g+5$; $k-5$...	11·7 11·7	11·7	
Nov. 1·3		173	$k-0-1$ ...	12·2 12·1	12·15	Hazy and moonlight.
3·3		70 173	... ...	12·5 13·0	12·75	A glimpse object in bright moonlight. Considerably less than *k* (12·2).
13·3		70 191	... ...	13·3 est.	13·3 est.	Clear. *k* has a small comes preceding it.
15·3		...	Considerably < *k*	13 13·3	13·2	
18·3		70	... ...	13·3 est.	13·3 est.	
29·3		191	Glimpsed? ...	13·5 est.?	13·5?	A glimpse object.
Dec. 14·3		191?	Glimpsed feebly	14 ±	14 ±	
30·3		...	Not seen ...	Under 13·5?	< 13·5?	Moderately good. Moonlight.
1866.						
May 4·5		70 191	... ...	13·5?	13·5?	Glimpsed feebly. Stars low.
16·4		70 191	... ...	13·7 ± est.	13·7 ±	
19·5		70 191	A glimpse object	13·7 ±	13·7 ±	
23·4		89	... ...	13·3 est.	13·3 est.	
June 7·4		89	$g+2+3$; $k-7$	11·4 11·5 11·5	11·5	
14·4		...	$e-0-1$; $g-7-8$	10·8 10·7 10·5 10·4	10·6	Gauged 10·6 in finder.
22·4		70 89	$d+4+5$ ...	10·1 10·2	10·15	
25·4		70	$=d$	9·7	9·7	
July 9·4		70	$c+3$; $d-4$...	9·3 9·3	9·3	Ruddy.
10·5		70	$c+2$; $d-5$...	9·2 9·2	9·2	Ruddy.
14·4		70	$c+4$; $d-3$...	9·4 9·4	9·4	Slightly ruddy.
19·4		70	$c+4$; $d-3$...	9·4 9·4	9·4	Ruddy.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866. July 20·5	h m	70	$c+4+5$? $d-2$?	9·4 9·5 9·5?	9·5?	
Aug. 3·5		70	$c+3$; $d-3$ ...	9·3 9·4	9·35	
9·4		70 89	$c+6$; $d-1$ ...	9·6 9·6	9·6	Ruddy orange.
16·4		70 102	$d+6$; $e-5$ ...	10·3 10·3	10·3	10·3 gauged.
21·4		70	$=e$	10·8	10·8	Rather oppressed by moonlight.
27·4		173	$=e$	10·8	10·8	e est. 10·7. Clds. coming up. Fair. Wind S.W.
31·5		70	$e+3$; $g-1$ ...	11·1 11·1	11·1	
Sept. 11·3		70	$g+1+2$ ...	11·3 11·4	11·35	e certainly more than $0^m·4 > g$.
14·3		70	$g+3$; $k-7$ ...	11·5 11·5	11·5	
Oct. 8·3		70	... ...	13·0 est.	13·0 est.	
Nov. 3·3		70	Not seen ...	Under 13	<13	Hazy.
1867. May 3	12 30 ±	70	A few tenths $>e<g$	11·0 ±	11·0 ±	
7	12 ±	70	$e+0+1$ ...	10·7 10·8	10·75	e hardly so faint as 10·8 mag.
21	11 ±		$d+2$; $e-9$ ...	9·9	9·9	
23	11 30	70	$d+2+3$; $e-8$	9·9 10·0 10·0	10·0	10·0 est. 4½-inch aperture.
24	12 45	70	$=d$	9·7	9·7	4½-inch aperture.
June 1	13 50	70	$d+2$; $e-9$ ...	9·9 9·9	9·9	5-inch aperture.
4	11 15	70	$d+2$; $e-9$ ...	9·9 9·9	9·9	3·7-inch aperture.
10	12 —	70	$c+4+5$; $d-2-3$	9·4 9·5 9·5 9·4	9·45	Ruddy decidedly. Mrs. Knott agrees with me that T is decidedly brighter than d, and very decidedly less than c. Slightly ruddy.
26	12 ±	70	$c+4+5$; $d-3-2$	9·4 9·5 9·4 9·5	9·45	5-inch aperture. Ruddy. So Mrs. Knott.
28	11 ±	70	$d-5$... ...	9·2	9·2	9·2 est. Qu. c not so bright as 9·0? T very fine ruddy orange. 5-inch aperture.
July 4	10 50	70	$c+2+3$; $d-4$	9·2 9·3 9·3	9·3	Aperture red. to 3·2 inch.
5	12 —	70	$c+4$; $d-3$ ...	9·4 9·4	9·4	Decidedly ruddy. Ap. 5-inch.
8	10 45	70	$c+2+3$; $d-4-5$	9·2 9·3 9·3 9·2	9·25	
9	11 10	70	$c+2$; $d-5$ ...	9·2 9·2	9·2	Slightly ruddy? 5-inch aperture.
16	11 15	70	$c+3$; $d-4$ ...	9·3 9·3	9·3	Decidedly ruddy. 5-inch aperture.
27	10 30 ±	70	$d+1$; $e-10$	9·8 9·8	9·8	Ruddy.
31	10 0	70	$d+6+7$; $e-4-5$	10·3 10·4 10·4 10·3	10·35	Hazy. 5-inch aperture.
Aug. 2	11 20	70	$d+5+6$; $e-5$	10·2 10·3 10·3	10·3	5-inch aperture. T rather ill-defined? Its light unsteady?
9	?	89	$d+8+9$; $e-2-3$	10·5 10·6 10·6 10·5	10·55	5-inch aperture.
12	10 45	70	$d+8$; $e-3$ ...	10·5 10·5	10·5	5-inch aperture. I do not think T to be fainter than on the 9th.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867. Aug. 20	h m 9 –	70	$e+2$; $g-2$...	11·0 11·0	11·0	5-inch aperture. Certainly $< e$.
21	13 30	70	$e+1+2$; $g-2-3$	10·9 11·0 11·0 10·9	10·95	[e a little brighter than T (Mrs. Knott)].
23	8 45	70 89	$e+2$; $g-2$...	11·0 11·0	11·0	Slightly ruddy? 5-inch aperture.
Sept. 3	10 15	89	$g+5$; $k-5$...	11·7 11·7	11·7	Slight haze at times.
4	8 15	89	$g+3$; $k-7$...	11·5 11·5	11·5	5-inch aperture. Fair observation.
10	10 20	89	$g+5$; $k-5$...	11·7 11·7	11·7	Moon troublesome.
Oct. 5	...	70 89	Not seen ...	Under 12	<12	Obs. doubtful. Sky hazy.
19	8 0±	191	Just glimpsed	$13\frac{3}{4}$ ±	13·75 ±	Very feeble.
Nov. 2	9 0±	191	Not seen ...	Under 13·5	$<13·5$	Clear.
23	8 –	70	Not seen ...	Under 13	<13	
Dec. 12	6 30±	191	Not seen ...	Under 12·5	$<12·5$	
1868. May 14	11 40	70	$c+2$; $d-5$...	9·2 9·2	9·2	$9\frac{1}{4}$ est. Slightly ruddy? Some hours from meridian.
23	11 0	70	$c+3$; $d-4$...	9·3 9·3	9·3	
26	11 10	70	$c+2$; $d-5$...	9·2 9·2	9·2	4-inch aperture. T decidedly ruddy.
27	11 55	70	$c+3$; $d-4$...	9·3 9·3	9·3	Decidedly pale red. Obs. a little doubtful.
June 13	10 45	70	$d+6$... ...	10·3	10·3	10·3 estimated.
23	11 30	70	... ...	10·5 est.	10·5 est.	Slight ruddy orange.
29	11 10	70	... ...	10·8 est.	10·8 est.	
July 13	10 35	70	... ...	11·0 11·0	11·0	Careful estimation.
20	10 50	70	... ...	$11\frac{3}{4}$ 12	11·9	Clear sky.
Aug. 10	12 0	89	... ...	$13\frac{1}{4}$ est.	13·25 est.	Sky clear between clouds.
Sept. 5	11 45	191	Not seen ...	Under 13	$<13·0$	
30	7 20±	70	Not seen ...	Under 11	$<11·0$	Flying clouds.
Oct. 7	8 20	191	Feebly glimpsed??	$14\frac{1}{4}$?	14·25?	Clear sky but bad definition.
23	8 10	89	Not seen ...	Under 12·5	$<12·5$	Slight haze at times.
Nov. 2	8 52	70	Not seen ...	Under 13	<13	Careful observation.
5	6 35	89 191	Not seen ...	Under 13·5 13·7	$<13·6$	Carefully looked for. Sky clear.
Dec. 19	7 40	89	Not seen ...	Under 13	<13	Sky clear.
23	7 20	70 191	Not seen ...	Under 13	<13	
1869. Jan. 5	7 20	70 89 191	Glimpsed? ...	13·5 ±	13·5 ±	Sky clear, but much disturbance.
June 15	11 5	89	$g+3$; $k-7$...	11·5 11·5	11·5	e I think not fainter than 10·5.
17	11 3	70	... ...	11·5 est.	11·5 est.	Clouds coming over.
29	12 20	70 89	... ...	12·3?	12·3?	Not $> k$ certainly.
July 10	11 15	89	$k+8$... ...	13·0	13·0	13 mag. est. Full aperture.
23	11 15	89	Not seen ...	Under 11	<11	Obs. difficult. Moonlight and light clouds.
Aug. 6	10 35	191	Glimpsed ...	13·7 ±	13·7 ±	Clearly seen at intervals.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869. Aug. 12	h m 10 20	89	Not seen ...	Under 13	< 13	Doubtfully glimpsed with 191 power?
17	10 10	191	Not seen ...	Under 13	< 13	*k* well seen. Moon bright.
24	8 38	191	Glimpsed??...	Under 13	< 13	Doubtfully glimpsed.
26	11 30	191	Not seen ...	Under 13	< 13	Not quite clear and obs. poor.
Sept. 20	10 50	191	Not seen ...	Under 12	< 12	Moonlight troublesome.
Oct. 9	7 10	89	Not seen ...	Under 13	< 13	Clear.
11	8 0	191	Not seen ...	Under 12	< 12	
26	7 0	191	Not seen ...	Under 13·5	< 13·5	Clear. *k* clearly in view.
Nov. 4	10 15	70	Not seen ...	Under 12½	< 12·5	
6	7 35	191	Not seen ...	Under 13·5	< 13·5	The faint star between *T* and *d* glimpsed.
10	8 40	191	Not seen ...	Under 13	< 13·0	Tolerably clear. Moonlight.
11	7 5	191	Not seen ...	Under 13·5	< 13·5	Clear. Moonlight.
20	6 40	191	Not seen ...	Under 12½	< 12½	Under 13 probably. *k* *well* seen. Hazy and moonlight.
28	8 40	70	Not seen ...	Under 13	< 13	
30	7 30	70	Not seen ...	Under 13	< 13	
Dec. 24	6 20	89 191	Glimpsed at times?	14?	14?	Doubtful observation.
1870. June 6	11 15	70	Not seen ...	Under 12½	< 12·5	*k* seen, but haze and sky illumined by Moon.
Oct. 15	8 35	191	Not seen ...	Under 13·5	< 13·5	But qu. feebly glimpsed at times?
26	7 20	191	Glimpsed at times	13·7 est.	13·7 est.	Clear.
1871. Jan. 12	6 45	70	$c+4$; $d-3$...	9·4 9·4	9·4	Stars rather low. *T* orange tint?
May 17	12 25	70	Not seen ...	Under 12½	< 12·5	*k* well seen.
June 5	11 0	70 156	Not seen ...	Under 13	< 13	*k* well seen. Clear.
26	11 0	156	Not seen ...	Under 12	< 12	
July 22	11 0	70 115	Not seen ...	Under 13	< 13	
29	10 25	115	Not seen ...	Under 12·2	< 12·2	*k* seen. Moon and haze.
Aug. 15	11 17	115	Not seen ...	Under 12	< 12	
31	10 55	70 115	Not seen ...	Under 12	< 12	*k* seen. Moonlight and light clouds.
Sept. 9	10 50	70 115	Not seen ...	Under 12·2	< 12·2	*k* seen.
Oct. 9	10 15	70 115	$g+8$; $k-2$...	12·0 12·0	12·0	12 mag. est. Clear.
12	11 10	70 115	$g+5$; $k-5$...	11·7 11·7	11·7	Clear.
23	8 25	70	... ...	10¾ est.	10·75 est.	Rather less than *e*, which seems decidedly brighter than 10·8 mag. more like 10·6.
Nov. 18	6 40	70	$c+4$; $d-3$...	9·4 9·4	9·4	Ruddy orange. Moonlight.
29	6 35	70	$c+4$; $d-3$...	9·4 9·4	9·4	Ruddy. These light-estimates were made before I noticed the obs. of November 18, which give the same results
Dec. 4	8 30	70	$c+4$; $d-3$...	9·4 9·4	9·4	*T* decidedly orange red.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871.	h m					
Dec. 29	5 25	70	$b+3$; $c-2$...	8·8 8·8	8·8	Decidedly ruddy. Twilight.
1872.						
Jan. 6	6 30	70	$b+5$; $=c$; $d-7$	9·0 9·0 9·0	9·0	Decidedly ruddy. 5^h past meridian and definition unequal.
May 27	12 30	115	Not seen ...	Under 13	< 13	*k well* seen.
June 13	11 45	115	Not seen ...	Under 12	< 12	
29	11 25	115	Not seen ...	Under 12·5	< 12·5	
July 9	10 45	115	Not seen ...	Under 12·5	< 12·5	*k* well seen.
Aug. 27	11 57	115	Not seen ...	Under 12	< 12	
31	10 35	115	... ...	13·5 est.	13·5 est.	Well seen at times.
Sept. 5	8 20	115	... ...	13·5 est.	13·5 est.	Well seen by glimpses.
16	11 0	115	Not seen ...	Under 12	< 12	*k* seen. Field flooded with bright moonlight. Moon just full.
19	11 6	89	Glimpsed ...	12½ 13	12·75	Moonlight. Magn. estimates worthless.
21	10 15	115	... ...	13 est.	13 est.	Fairly seen. Considerably less than *k*.
Oct. 7	9 5	70 115	$e+5$; $g+1$...	11·3 11·3	11·3	11¼ 11½ est. Brightening up.
9	10 20	70	$e+4$; $=g$ ...	11·2 11·2	11·2	
18	8 35	70	$d+8$; $e-3$...	10·5 10·5	10·5	Moonlight. Clouds cleared off after a wet day.
22	8 50	70	$d+7$; $e-4$...	10·4 10·4	10·4	Slightly ruddy?
28	10 15	70	$d+5$; $e-6$...	10·2 10·2	10·2	Hazy.
Nov. 7	8 10	70	$d+0+1$; $e-10$	9·7 9·8 9·8	9·8	Slightly ruddy.
12	8 50	70	$=d$	9·7	9·7	Ruddy.
23	8 0	70 115	$d+3$; $e-8$...	10·0 10·0	10·0	Ruddy. Certainly less than *d*, a stiff gale blowing from S.S.W.
Dec. 4	8 5	70	$d+7$; $e-4$...	10·4 10·4	10·4	Much less than *d* and nearer to *e*.
9	8 35	70	$d+10$; $e-0-1$	10·7 10·8 10·7	10·7	Moonlight and clouds troublesome. *T* as nearly as can be judged equal to *e*.
1873.						
Jan. 2	6 40	115 191	$e+9$; $g+5$; $k-5$	11·7 11·7 11·7	11·7	Stars rather low and atmosphere moist. Obs. not very satisfactory.
1876.						
Nov. 29	7 50	191	Not seen ...	Under 12½	< 12½	*k* well seen.
1877.						
May 4	12 10	70	$d+11$; $=e$...	10·8 10·8	10·8	Clear sky. Well seen 11 ± est.
15	12 25	70	$d+7$; $e-4$...	10·4 10·4	10·4	Decidedly ruddy.
June 9	10 35	70 115	$c+7$; $=d$; $e-11$	9· 9·7 9·7	9·7	Ruddy orange.
20	10 50	115	$d+4+5$? $e-6-7$?	10·1 10·2 10·2 10·1	10·15	Certainly decidedly less than *d*. Obs. difficult. Hazy.
23	11 25	115	$d+5$; $e-6$...	10·2 10·2	10·2	About 10 mag. est.
25	11 55	70	$d+5$; $e-6$...	10·2 10·2	10·2	About 10 mag.; ruddy?
29	11 50	70	$d+7$; $e-4$...	10·4 10·4	10·4	A clear sky.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877.	h m					
July 7	11 10	70	$d+7$; $e-4$...	10·4 10·4	10·4	Clear. Well seen.
17	11 40	70	$d+10$; $=e$...	10·7 10·8	10·75	Clear. Bad definition.
26	10 23	115	$e+2$; $g-2$...	11·0 11·0	11·0	Abt. 11 mag. est.
30	11 30	115	$e+3+4$; $g-0-1$	11·1 11·2 11·2 11·1	11·15	Clear. A ground mist rising.
Aug. 7	11 15	115	$e+3+4$; $g-0-1$	11·1 11·2 11·2 11·1	11·15	Clear sky.
15	10 20	115	$g+5$; $k-5$...	11·7 11·7	11·7	Fair observation.
17	10 15	115	$g+7$; $k-3$...	11·9 11·9	11·9	Fair obs. A bright 12 mag. est. About one whole mag. less than *e*.
Sept. 27	10 35	115	Glimpsed ...	13½ est.	13·5 est.	Slight haze.
Oct. 4	11 30	115	Not seen ...	Under 13·5	< 13·5	Small star preceding *T* (between *T* and *d*) seen.
Dec. 10	6 35	115 191	Not seen ...	Under 12½ 13	< 12¾	
27	7 10	115	Not seen ...	Under 13	< 13	Clear. *k* well seen.
1878.						
[M]ay 21	11 55	70	$=d$; $d-1$? $e-11-12$	9·7 9·6 9·7 9·6	9·65	Ruddy.
25	11 35	70	$c+6$; $d-1$...	9·6 9·6	9·6	Ruddy.
June 6	12 0	70 115	$d+3$? ...	10·0	10·0	*e* brighter than 10·8? *T* about 10 mag.
12	11 10	70	$d+8$? $e-3$?	10·5 10·5	10·5	A rather doubtful observation.
25	12 10	70	$=e$; $d+11$...	10·8 10·8	10·8	Clear. Fair obs.
July 13	11 5	115	$g+1$... ...	11·3	11·3	11½ est. *e* brighter than 10·8 mag.? More like 10·5?
Aug. 1	10 50	89	$=k$? $k+$? ...	12·2 12·2+?	12·2	12¼ est.
Oct. 17	8 35	115 191	Not seen ...	Under 13·5	< 13·5	Small star between *T* and *d* glimpsed.
Nov. 1	8 55	115	Not seen ...	Under 12½ 13	< 12½ 13	*k* seen.
16	6 40	191 115	Not seen ...	Under 13?	< 13?	*k* well seen. The small star between *T* and *d* glimpsed.
1879.						
June 9	11 25	115	$k-2$ ...	12·0	12·0	About 12 mag. est. Rather brighter than *k*.
July 23	10 15	115 191	Not seen ...	Under 12½	< 12½	*k* seen. Haze troublesome.
24	11 40	191	$k+10+12$ ...	13·2 13·4	13·3	13¼ 13½ est. *k well* seen.
Aug. 11	10 40	115	Glimpsed ...	13·5 13·7?	13·6?	About equal in mag. to small star between it and *d*, which also glimpsed.
Oct. 11	7 30	191	Not seen ...	Under 13	< 13	Under 13. The small star nearer *d* visible.
15	10 5	191	Not seen ...	...	13½?	The small star nearer *d* seen at times.
Nov. 12	8 22	70	...	...	13 est.	At least ¾ mag. less than *k*.
18	7 40	115	$k+5$... ...	12·7	12·7	12¾ est.
Dec. 8	7 50	70 115	$g+7$; $k-3$...	11·9 11·9	11·9	

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1880.	h m					
June 7	11 15	191	Not seen ...	Under 13	< 13	*k* well seen. Qu. *T* once or twice suspiciously glimpsed.
July 29	11 15	115	Not seen ...	...	< 13	
Aug. 10	11 10	115	Not seen ...	Under 13?	< 13?	The small star between *T* and *d* glimpsed.
Sept. 29	8 0	115	Not seen ...	Under 13	< 13	
Oct. 11	8 0	115	Not seen ...	Under 12½	< 12½	
23	8 15	115	Feebly glimpsed?	...	< 13·7 ?	Doubtful.
Nov. 19	8 30	115	...	...	13·0 est.	Distinctly visible.
25	8 25	115	...	...	13·0 est.	
1881.						
Jan. 3	6 40	70 115	$=e$; $d+11$ ...	10·8 10·8	10·8	
7	6 56	70	$=e$	10·8	10·8	6^{h} past meridian.
June 23	11 20	70	Not seen ...	Under 12½	< 12½	
July 4	10 55	70 115	Not seen ...	Under 12½	< 12½	*k* seen.
Aug. 4	10 5	115	Not seen ...	Under 12	< 12	
Sept. 26	7 15	115	...	...	13 est.	About 1^{m} < *k*.
28	9 0	115	...	...	13 est.	
Oct. 4	9 12	115	$k+3$... ...	12·5	12·5	About 12½ est.
15	8 55	115	11·8 12·0 ...	11·9	11·9	Half mag. > *g*.
19	8 25	115	$g+5$; $k-5$...	11·7 11·7	11·7	
Nov. 15	8 3	70	$d+7$; $e-4$...	10·4 10·4	10·4	
17	6 50	70	$d+3$; $e-8$...	10·0 10·0	10·0	Ruddy? 10 mag. est.
23	8 45	70	$=d$	9·7	9·7	9·7 gauged. So, too, *d*. *T* orange tint?
28	8 45	70	$c+4$; $d-3$...	9·4 9·4	9·4	Orange tint. Moonlight.
Dec. 3	7 10	70	$b+3$; $c-2$...	8·8 8·8	8·8	So, too, in finder. *T* orange tint. Moonlight and rather cloudy.
5	8 38	70	$b+2$; $c-3$...	8·7 8·7	8·7	Bright moonlight and hazy sky.
8	7 10	70	$b+2$; $c-3$...	8·7 8·7	8·7	Ruddy. Not brighter than *b*. So, too, in finder.
13	7 8	70	$\frac{1}{2}(b+c)$ ...	8·75	8·75	Ruddy orange. Obsd. in finder as well as in telescope.
"	7 20	70	$\frac{1}{2}(b+c)$ ...	8·75	8·75	With 3·7 in. aperture in telescope.
20	6 30	70	$b+5$; $=c$; $d-7$	9·0 9·0 9·0	9·0	Orange tint. A clear sky, but a very high wind blowing. *T* on the decline?
23	6 40	70	$c+1+2$; $d-5-6$	9·1 9·2 9·2 9·1	9·15	Qu. *b* not brighter than *c*? *T* orange tint.
"	6 50	70	$c+2+3$; $d-4$	9·2 9·3 9·3	9·3	With 3·7 in. aperture.
29	6 30	70	$c+2+3$ $d-5-4$; $b+7$	9·2 9·3 9·2 9·3 9·2	9·25	Slightly ruddy. 3·2 in. aperture in telescope.

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1882. Jan. 4	h m 6 25	70	$c+6+7$; $d-1-0$	9·6 9·7 9·6 9·7	9·65	Moonlight (full Moon) and haze. Obsd. with full aperture and 3-in. aperture.
7	6 30	70	$d+2$ ...	9·9	9·9	With full aperture *T* very nearly equal *d*, with 2·7 in. aperture in telescope and in finder, decidedly less. Clear. A high wind.
June 15	10 30	115	Not seen ...	Under $12\frac{1}{2}$	$<12\frac{1}{2}$	*k* well seen.
July 24	10 37	115	Not seen ...	Under 13	<13	*k* well seen.
Aug. 9	10 15	115	Just seen ...	13·5?	13·5?	
Oct. 2	7 55	115	$=g$?... ...	11·2?	11·2?	$11\frac{1}{4}$ $11\frac{1}{2}$ est. Ruddy?
23	7 35	89	$=d$	9·7	9·7	Bad definition. Used aperture of 3 inches.
24	7 5	70	$=d$	9·7	9·7	Slightly ruddy.
Nov. 9	8 27	70	$=d$	9·7	9·7	Decidedly ruddy. $=d$ too in finder. *Not brighter* than *d* certainly.
17	6 40	115	$d+0+2$? $=d$	9·7 9·9 9·7	9·8	I cannot quite satisfy myself as to mag of *T*. Tried with full aperture and with 3·2 in. aperture. $=d$, I think.
28	5 55	70	$d+3$... ...	10·0	10·0	Gauged 10·0; *d* gauged 9·7.
Dec. 4	7 0	70	$d+5$; $e-6$...	10·2 10·2	10·2	*e* 10·7 10·8.
18	6 50	70 110	$d+10$; $e-0-1$; $g-4$	10·7 10·8 10·7 10·8	10·75	Little if at all $>e$. $10\frac{3}{4}\pm$ est.
1883. June 15	11 1	115	Not seen ...	Under $12\frac{1}{2}$	$<12\frac{1}{2}$	*k* seen.
30	11 5	115	Not seen ...	Under 13, $13\frac{1}{2}$	$<13\frac{1}{4}$	
July 4	11 15		Glimpsed at times	13·5	13·5	*T* and neighbour glimpsed at intervals
13	10 43	...	...	...	13·5	Fairly seen.
23	10 35	115	...	...	$12\frac{3}{4}$ est.	Well seen.
28	10 0	115	$k+6+7$ ...	12·8 12·9	12·85	$12\frac{3}{4}$ 13.
Aug. 21	8 50	115	$g+3$; $k-7$...	11·5 11·5	11·5	About $11\frac{1}{2}$ mag.
24	10 7	70	$g+1$... ...	11·3	11·3	
Oct. 2	7 20	70	$=d$	9·7	9·7	With full and 3·2 in. aperture.
4	8 0	70	$=d$	9·7	9·7	Slight orange tint.
9	8 30	70	$=d$	9·7	9·7	
23	8 20	70	$=d$; $d-1$ ...	9·7 9·6	9·65	Ruddy.
27	8 25	70	$d+3$; $e-8$...	10·0 10·0	10·0	Ruddy, slightly.
29	7 0	70	$d+7$; $e-4$...	10·4 10·4	10·4	Ruddy.
Nov. 10	6 55	115	$d+6$; $e-5$...	10·3 10·3	10·3	
17	7 20	70	$=e$	10·7	10·7	Gauged 10·7. So *e*.
21	8 32	70	$e+1$... ...	10·9	10·9	10·9 gauged.
26	7 35	70	$e+2$... ...	11·0	11·0	

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884.	h m					
June 30	11 10	115	$k+2+3$ ...	12·4 12·5	12·45	$12\frac{1}{2} \pm$ est.
July 17	11 7	70	$g+5$; $k-5$...	11·7 11·7	11·7	About $11\frac{3}{4}$ est.
Aug. 1	10 40	70	$d+11$; $=e$; $g-4$	10·8 10·8 10·8	10·8	
22	8 45	70	$d+1$; $e-10$	9·8 9·8	9·8	Ruddy.
23	8 40	70	$=d$	9·7	9·7	Ruddy.
Oct. 4	8 0	70	$c+3$; $d-4$...	9·3 9·3	9·3	Ruddy. Moon and haze.
13	7 50	70	$d+2$ ...	9·9	9·9	Certainly *not* so bright as *d*. Ruddy. Is there a mistake in the obs. of October 4?
16	8 0	70	$d+2+3$; $e-7$	9·9 10·0 10·0	10·0	10·0 gauged, *e* 10·7. Ruddy.
21	8 5	70	$d+4+5$; $e-7-6$	10·1 10·2 10·1 10·2	10·15	Ruddy. A rather faint 10 mag est.
24	8 5	70	$d+8$; $e-3$...	10·5 10·5	10·5	10·5. *e* 10·8 gauged.
28	8 35	70	$d+8$; $e-3$...	10·5 10·5	10·5	Slightly ruddy.
29	7 40	70	$d+8$; $e-3$...	10·5 10·5	10·5	*T* slightly ruddy.
Nov. 7	8 30	70	$=e$	10·8	10·8	So too in finder.
15	7 55	70	$e+3$... ...	11·1	11·1	
19	8 5	70	$e+2$; $g-2$...	11·0 11·0	11·0	(In the obs. book the entry was ($g+2$ $h-2$) but this must be a mistake. *g* is 11·2 mag. and *h* though lettered has no mag. assigned. In the column of *Deduced Mags.* the entry is (11·0 11·0) showing that the probable reading should be ($e+2$ $g-2$)).
Dec. 9	7 20	70	$g+7$; $k-3$...	11·9 11·9	11·9	
17	6 40	70	$k+3$... ...	12·5	12·5	
1885. May 15	11 30	115	Not seen ...	Under 12·2	< 12·2	*k* seen.
June 17	10 45	115	... ...	13 $13\frac{1}{4}$	13·1	Well glimpsed at times. *k* well seen.
July 10	11 25	110	$e+4$; $=g$ ...	11·2 11·2	11·2	
13	10 45	115	$e+2$; $g-2$...	11·0 11·0	11·0	
17	10 22	70	$e+0+1$ ...	10·8 10·9	10·85	
20	10 35	115	$=e$	10·8	10·8	
24	11 5	70	$d+9$; $e-2$...	10·6 10·6	10·6	
Aug. 10	11 58	70	$d+7$; $e-4$...	10·4 10·4	10·4	Ruddy.
27	10 0	70	$d+7$; $e-4$...	10·4 10·4	10·4	Moonlight.
29	9 55	115	$d+6+7$; $e-4-5$	10·3 10·4 10·4 10·3	10·35	*T* decidedly ruddy.
Oct. 1	8 10	70	$e+4$; $=g$ ...	11·2 11·2	11·2	
7	8 15	115	$g+5$; $k-5$...	11·7 11·7	11·7	
27	7 30	115	$k+4$ ...	12·6	12·6	$12\frac{1}{2}$ 13 est.
Nov. 17	6 55	115	13·5 est. ...	...	13·5	
1886. June 1	11 27	115	Not seen ...	Under $12\frac{1}{2}$ 13	< $12\frac{3}{4}$	(A mistaken obs. probably. See next entry)

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1886 June 23	h m 10 55	70	$b+2$; $c-3$...	8·7 8·7	8·7	Can the star I observed or looked for on June 1 have been *T*? White?
30	10 38	70	$b+1$; $c-4$...	8·6 8·6	8·6	*T* decidedly ruddy.
July 5	10 57	70	$b+3$; $c-2$...	8·8 8·8	8·8	Ruddy orange. In finder too $T=b+3$ $c-2$.
15	11 20	70	$b+7$; $c+2$; $d-5$	9·2 9·2 9·2	9·2	Ruddy. Moonlight and sky not quite clear.
24	10 35	70	$d-1$ ...	9·6	9·6	
Aug. 10	10 25	70	$d+10$; $e-1$	10·7 10·7	10·7	
Sept. 30	8 15	115	... ...	13 est.	13	Small star preceding *T* also seen, 13·7 ±.
Nov. 16	8 12	115	Not seen ...	Under 13·5	< 13·5	
1887. June 13	11 30	70	$c+5$; $d-2$...	9·5 9·5	9·5	Ruddy.
18	10 35	70	$c+4$; $d-3$?	9·4 9·4	9·4	Obs. a little doubtful.
30	10 45	70	$d+4$; $e-7$...	10·1 10·1	10·1	Ruddy.
July 18	12 45	115	$e+1$; $g-3$...	10·9 10·9	10·9	
Oct. 19	9 0	115	Not seen ...	Under 13·5	< 13·5	*k* seen.
1888. May 3	10 50	115	Glimpsed ...	13·5	13·5	
Aug. 13	9 55	191	Glimpsed ...	13·5	13·5	Minute star between *T* and *d* also glimpsed.
Oct. 5	8 35	115 191	Not seen ...	Under 13·5	< 13·5	Star between *T* and *d* seen.
11	10 15	115	Not seen ...	Under 13·5	< 13·5	
19	8 35	115	Not seen ...	Under 13	< 13·0	*k* well seen.
27	8 15	115	Not seen ...	Under 13 5?	< 13·5?	*k* well seen.
Dec. 6	6 48	115	Not seen ...	Under 13	< 13	*k* well seen. Rather hazy.
1889. Aug. 7	10 0	115	Not seen ...	Under 12·2	< 12·2	*k* seen.
Sept. 6	8 3	110 115 191	Not seen ...	Under 11	< 11	*g* glimpsed? Moonlight and haze troublesome.
10	8 53	115 191	Not seen ...	Under 13	< 13	*k* well seen.
Oct. 21	9 42	115	Not seen ...	Under 13	< 13	*k* well seen. Small star between *T* and *d* glimpsed?
25	7 25	115 191	Not seen ...	Under 13·5	< 13·5	
31	8 0	70 115	Not seen ...	Under 13·3	< 13·3	
Nov. 2	7 20	191	Not seen ...	Under 13	< 13	
12	7 23	115	... ...	13·7 ±	13·7 ±	Well seen at times, as also small star between it and *d*, which is about same mag. as *T*.
25	6 15	115	... ...	13·3	13·3	Seen pretty easily.
30	7 55	115	13·2 est. ...	13·2	13·2	A mag. less than *k*.
Dec. 12	6 40	115	$g+5$... ...	12·7	12·7	12¾ 13 est.
1890. Aug. 1	10 16	115	Not seen ...	Under 12·5	< 12·5	*k* seen. Hazy sky and bright Moon.
4	11 0	115	Not seen ...	Under 12½	< 12·5	*k* seen.

T Delphini—continued.

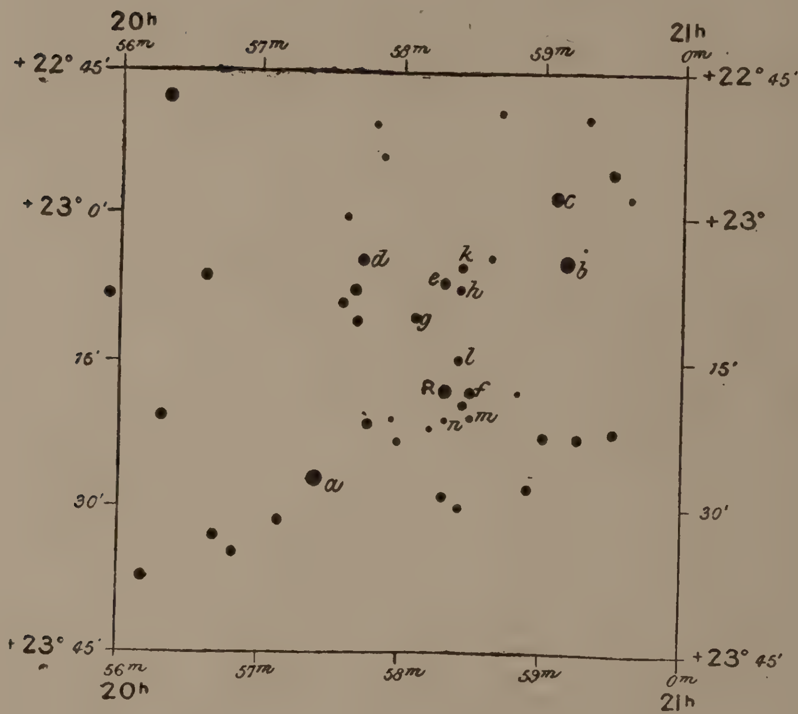
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1890.	h m					
Aug. 23	10 20	115 191	Glimpsed ...	13·7	13·7	Comes also glimpsed. Brighter?
27	9 51	115	Not seen ...	Under 13	< 13	Moonlight and slightly hazy sky.
Sept. 4	10 3	115 191	Not seen ...	Under 13·5	< 13·5	Star between *T* and *d* glimpsed.
8	9 57	70 115 191	Not seen ...	Under 13·5	< 13·5	
13	8 27	115	Not seen ...	Under 13·5	< 13·5	Star between *T* and *d* seen.
Oct. 25	8 20	115	Not seen ...	Under 12	< 12	Sky hazy and moonlight.
Nov. 1	6 20	115	13·2 est. ...	13·2	13·2	Well seen. Light rather unsteady? Star between *T* and *d* also well seen (13·7?).
4	7 25	115	$k+6$... ...	12·8	12·8	A bright 13 mag.
9	7 25	70 115	$k+2$... ...	12·4	12·4	Light of *T* rather unsteady? Looks large at times? Something the appearance of *U Geminorum*. Small star between *T* and *d* seen. Clear sky.
13	8 5	70 89	$k+1+2$ ...	12·3 12·4	12·35	Seems to twinkle more than *k*.
28	6 54	115	$e+4$; $=g$ ...	11·2 11·2	11·2	
Dec. 1	6 37	115 70	$e+2$; $g-2$...	11·0 11·0	11·0	
7	6 15	70	$e-1$; $g-5$...	10·7 10·7	10·7	Ruddy.
9	6 6	115	$e-2$... ...	10·6	10·6	
10	7 6	70 115	$e-2$... ...	10·6	10·6	
12	7 55	70	$d+8$; $e-3$...	10·5 10·5	10·5	
13	6 52	110	$d+8$; $e-3$...	10·5 10·5	10·5	
22	6 10	70	$d+3$; $e-8$...	10·0 10·0	10·0	*T* ruddy. Rather large disc?
1891.						
Jan. 1	6 15	70 115	$=d$; $e-11$...	9·7 9·7	9·7	Ruddy.
21	6 32	70 115	$d+0+1$ ...	9·7 9·8	9·75	Ruddy.
Feb. 1	6 20	70	$d+3$... ...	10·0	10·0	Stars low. Obs. rather doubtful.
June 5	11 30	115	Not seen ...	Under 11	< 11·0	Very doubtful obs.
July 28	10 20	115 191	Not seen ...	Under 13·5	< 13·5	Small star between *T* and *d* seen at times.
Aug. 10	9 55	115	Under 13·5?...	Under 13·5?	< 13·5	Glimpsed once or twice? Very doubtful. Small star between *T* and *d* glimpsed.
12	10 10	115 191	Not seen ...	Under 13·5	< 13·5	Star between *T* and *d* doubtfully glimpsed.
Sept. 4	8 0	115	Not seen ...	Under 13	< 13	
Oct. 12	9 5	70 115	$k+4$... ...	12·6	12·6	
15	9 53	115	$k+2$... ...	12·4	12·4	Moon bright and sky rather hazy.
23	8 37	115	$g+2$... ...	11·4	11·4	Clouds coming up. About $\frac{3}{4}^{m}$ less than *e*.
28	7 0	70 115	$e+5$; $g+1$...	11·3 11·3	11·3	Looks rather *hazy*?
Nov. 3	7 47	70 115	$e+2$; $g-2$...	11·0 11·0	11·0	*T* rather large and hazy?
5	7 25	70	$e+1$; $g-3$...	10·9 10·9	10·9	Slightly ruddy. Large?
7	8 26	70 115	$e-1$... ...	10·7	10·7	Orange ruddy.
11	8 41	70	$d+9$; $e-2$...	10·6 10·6	10·6	Ruddy. (A gale subsiding.)

T Delphini—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1891.	h m					
Dec. 17	6 2	70	$d+6$; $e-5$ ...	10·3 10·3	10·3	Ruddy slightly.
19	6 43	70	$d+8$; $e-3$ ...	10·5 10·5	10·5	
1892.						
Jan. 4	6 46	70 115	$d+10+11$; $e-0-1$	10·7 10·8 10·8 10·7	10·75	Fairly seen.
7	6 10	70 115	$e+1+2$ ...	10·9 11·0	10·95	Pretty well seen.
May 30	11 35	115	Not seen ...	Under 13·5	<13·5	k seen. Small star between T and d not seen.
July 10	10 35	115	Not seen ...	Under 12·5	<12·5	Hazy. Moon rising. k seen.
28	10 27	115	... ...	...	13·5?	Glimpsed at times. 13·5? Comes between T and d not seen.
Aug. 15	10 15	115	$k+10$ ...	13·2	13·2	About 13·2 est. Four or five tenths brighter than small star (also seen) between it and d, which is probably about 13·6 13·7.
Sept. 24	7 30	70	$e+2$; $g-2$ ...	11·0	11·0	
Oct. 11	8 2	70 115	$d+1$; $c+6$ ...	9·6 9·6	9·6	Slight orange tint.
15	7 40	70	$c+5$; $d-2$ ...	9·5 9·5	9·5	Ruddy. 9·4 gauged. d gauged 9·7.
17	7 50	70	$c+4$; $d-3$ ...	9·4 9·4	9·4	Orange ruddy. 9·4 gauged.
20	7 15	70	$c+2$; $d-5$ ...	9·2 9·2	9·2	9·2 gauged. Orange ruddy. Well observed.
22	7 23	70	$=c$	9·0	9·0	c and T 9·0 gauged. T orange tint.
Nov. 3	8 30	70	$c-1$	8·9	8·9	Very ruddy. Moon bright, and haze.
10	7 6	70	$c+4+5$; $d-3-2$	9·4 9·5 9·4 9·5	9·45	Orange tint. Decidedly on the wane. A fair obs. Sky rather hazy.
18	7 43	70 115	$d+4$; $e-7$ ...	10·1 10·1	10·1	Slight orange tint.
24	7 20	70 115	$d+5$; $e-6$ ...	10·2 10·2	10·2	(A clear sky rapidly clouded over, with a warm temperature. Outside thermometer 43°. Instrument and walls running down with moisture.)
26	8 43	115	$d+7$; $e-4$ ...	10·4 10·4	10·4	Slightly ruddy? Disc a little large.
30	7 0	70 115	$d+7$; $e-4$ ...	10·4 10·4	10·4	Slightly ruddy?
Dec. 12	6 31	115	$d+9$; $e-2$ ...	10·6 10·6	10·6	A rather hazy sky.
30	6 47	70	$e+3$	11·1	11·1	Far from meridian. Moonlight and haze.
1893.						
Aug. 4	10 7	115	$g+4$; $k-6$ ...	11·6 11·6	11·6	
7	10 18	115	$g+2$; $k-8$ ...	11·4 11·4	11·4	
14	10 30	70	$e+4$; $=g$ ...	11·2 11·2	11·2	
Sept. 30	7 57	70	$c+6$; $d-1$ ...	9·6 9·6	9·6	Orange ruddy.
Oct. 4	8 8	70	$c+5$; $d-2$ ...	9·5 9·5	9·5	Ruddy decidedly.
12	7 30	70	$c+7$; $=d$ ...	9·7 9·7	9·7	Slightly ruddy.
19	7 30	70	$d+1$	9·8	9·8	Orange ruddy.
27	6 30	70	$d+5$; $e-6$ ...	10·2 10·2	10·2	Orange ruddy.
Nov. 6	7 37	70	$d+8$; $e-3$ ...	10·5 10·5	10·5	Slightly ruddy.
7	7 25	70	$d+8$; $e-3$ ...	10·5 10·5	10·5	Orange tint.
13	7 50	70	$=e$	10·8	10·8	
Dec. 30	7 0	115	$=k$	12·2	12·2	5^h past meridian. Doubtful obs.

Mr. KNOTT'S Diagram, Epoch 1865 ?

R Vulpeculæ.



Adopted magnitudes of Comparison Stars :

a	=	7·1	*g*	=	10·0
b	=	7·3 ± (variable)	*h*	=	10·5
c	=	8·3	*k*	=	10·9
d	=	9·1	*l*	=	11·4
e	=	9·5	*m*	=	11·9
f	=	9·7	*n*	=	12·6

R Vulpeculæ.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 7560 *R Vulpeculæ*, R.A. for 1900·0=20^h 59^m 56^s, Decl.=+23° 25′·5

Annual Variation +2^s·66 and +0′·24.

R.A. for 1855·0=20^h 57^m 56^s, Decl.=+23° 14′·9.

Redness=2·0. Max. magnit.=7·5–8·5. Min.=12·5–13·6.

M–m=62^d·0.

Maximum, 1865 Sept. 18=2402498·0^d (Julian).

Formula representing Period+136^d·90. E+18 sin (4° E+80°).

(From 30 observations of max. and 11 of min., including observations in 1807, 10, 59–95.)

Discovered at Bonn, 1858. 9^m·5 foll. 6^s, 0′·3 N.

R Vulpeculæ.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1861. Sept. 7	h m	60	... ...	9·3 est.	9·3	Is not this star P.xx. 457? It has a 10 mag. comes.
9		60	... ...	9·3	9·3	Shines with a steady light.
10		60	... ...	9·3	9·3	
26		60	$l+1$; $m-3$...	11·5 11·6	11·55	Bad definition.
30		89?	$m+2$; $n-3$	12·1 12·3	12·2	$3\frac{1}{4}^h$ past meridian. Fair obs.
Oct. 2		60	$m+4$; $n-1$	12·3 12·5	12·4	Fair obs. Not good definition.
3		60	$n-3$... ...	12·3	12·3	
7		60	$n+1$... ...	12·7	12·7	Good.
8? 9?		60	$n+2+3$ ...	12·8 12·9	12·85	
10		60	$n+4$... ...	13·0	13·0	Bad night. *R* scarcely visible.
15		191	$n+5$... ...	13·1	13·1	Moonlight. *R* hardly visible.
18		191 258	13·4 13·5 est.	...	13·5	*R* only just visible. Bright moonlight.
26		60 191 258	Not seen ...	Under 13·5	< 13·5	4^h past meridian. Good.
Nov. 2		191	13·4 est. ...	...	13·4	Visible by glimpses. Tolerably clear.
5		191	$n+6$... ...	13·2	13·2	Also just visible with 60 power.
7		191	13·2 13·3 est.	13·2 13·3	13·25	Fair obs. Tolerably clear.
18		60 191	$l+2$; $m-2-3$; $k+7$	11·6 11·7 11·6 11·6	11·6	Scintillates strongly. Moonlight.
20		60	$h+7+8$; $l-1$	11·2 11·3 11·3	11·3	Moonlight. Definition very bad.
23		60	$=h$; $l-3-4$; $f+8+10$	10·5 11·1 11·0 10·5 10·7	10·8	Definition good. Hazy.
27		60	$f+3$; $h-4$; $l-11$	10·0 10·1 10·3	10·1	
30		60	$f+1$; $h-7$; $e+4$	9·8 9·8 9·9	9·8	Fair obs. Clear.
Dec. 2		60	$=f$	9·7	9·7	
4		60	$f-1$; $e+4$; $=f$	9·6 9 9 9·7	9·8	Fair obs.
5		60	$=f$; $e+3$	9·7 9·8	9·75	Hazy. Still.
26		60	$e-5$; $a+10+12$; $f-12$	9·0 8·1 8·3 8·5	8·5	*R* slightly ruddy?
1862. Jan. 2·2		60	$e-10$; $a+10$; $f-16$	8·5 8·1 8·1	8·2	Twilight. Clear. Fair obs.
3·3		60	$e-5$; $b+12$...	9·0 8·5	8·75	Very hazy. 5^h past meridian.
4·3		60	$e-8$; $a+15$...	8·7 8·6	8·65	Not very good. 5^h past meridian.
8·2		60	$e-5$; $a+16$; $b+13$; $f-15$	9·0 8·7 8·6 8·2	8·6	Est. 8·7. Orange red??
17·3		60	$e-2$; $f-7$...	9·3 9·0	9·2	Very hazy. Snow in air. Cold. Fair obs.
18·3		60	$e-3$; $d-1$...	9·2 9·0	9·1	Hazy.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1862.	h m					
Jan. 24·3		60	$e+2$; $f-2$ ...	9·7 9·5	9·6	Fair observation.
Feb. 7·3		191	$l+1$? ...	11·5	11·5	Low, and very faint and difficult.
July 25·4		191	13·4 estimated	...	13·4	Superb evening.
Aug. 27·4		60 102	$=f$	9·7	9·7	Good observation.
Sept. 16		60 102	$f-8$... ...	...	...	Fair.
23·3		102	$e-12$; $b+8$	...	...	Fine night.
27·3		...	... ...	...	...	8·5 est.
30·3		60	... ...	...	...	Fair observation. *R* ruddy?
Oct. 1·3		60 102	... ...	...	...	Ruddy?
6·4		60 102	... ...	...	...	Bright moonlight.
8·3		60 102	... ...	...	...	Bright moonlight. Ruddy?
10·3		102	8·3 est. ...	...	8 3	Hasty observation.
20·3		60 102	... ...	...	...	Ruddy or orange?
23·3		60 102	... ...	...	...	
Nov. 3·3		102	... ...	...	...	Bright moonlight. Fine.
1863. July 7		60	$b+1$; $c-6$ ...	7·4 7 7	7·55	Ruddy yellow?
10·3		60	$b+2+1$ ...	7·5 7·4	7 45	Ruddy yellow?
15		60	$b+3$; $c-2$ ...	7·6 8·1	7·85	Slightly ruddy? Hazy.
Aug. 12		60	$h+2$; $k-3$; $l-6$	10·7 10 6 10·8	10·7	Est. $10\frac{3}{4}$ mag.
17		60	$h+3$; $l-2$ ...	10·8 11·2	11·0	Very bad. Clouds came up.
20		60	$l+2$; $m-2$...	11·6 11·7	11·65	Bad.
24		60	$m+1+2$ ...	12·0 12·1	12·05	Fair observation. *R* est. 12·0.
Sept. 7		60	$n+1$ ...	12 7	12·7	Fair. *R* 12·7 12·8 mag.
17		102	13·0 13·2 est.	13·0 13·2 est.	13·1	Fine night.
23		173	$n+3+4$ ...	12·9 13·0	12·95	Moonlight.
28		102	$m+3$; $n-5$...	12·2 12·1	12·15	Fine night. Moonlight.
Oct. 1		102	$n-3$... ...	12·3	12 3	
6		102	$l+1$; $m-3$ ..	11·5 11·6	11·55	Clear night.
13		102	$g+3$; $h-2$...	10·3 10·3	10·3	Fine.
21		102	$=d$; $d-1$; $f-6$	9·1 9·0 9·1	9·1	
23		...	$d-1-2$; $c+5$	9·0 8·9 8·8	8·9	Bright moonlight. Hazy.
28		...	$c+5$; $d-4$...	8·8 8·7	8·75	Field very doubtful on account of bright moonlight and distance from meridian.
29·3		60	$c+2$; $d-6$...	8·5 8·5	8·5	Moon rising. Fine. [Baxendell 8·3 obs. by letter.]
30		60	$c+1$; $d-7$...	8·4 8·4	8·4	[Baxendell 8·2.]
Nov. 9·3		60	$c-5$... ...	7·8	7·8	Slightly ruddy.
10·4		60	$c-5$; $\frac{1}{2}(b+c)$	7·8 7·8	7·8	Ruddy? Clear.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1863.	h m					
Nov. 12		60	$c-4$	7·9	7·9	
19		60	$b+4$; $c-8$ ...	7·7 7·5	7·6	$b=a+1+2$ [=7·2 7·3]. [Bax. 7·5. Bird. 7·6.]
28		60	$\frac{1}{2}(b+c)$; $c-5-6$	7·8 7·8 7·7	7·8	Slightly ruddy?
30		60	$c-5$	7·8	7·8	
Dec. 2		60	$c-4$	7·9	7·9	
3		60	c; $c-1$ ...	8·3 8·2	8·25	
10		60	$c+1$	8·4	8·4	a very decidedly deeper in colour than b and decidedly ruddy. $b=a+3$?
14		60	$c+2$; $d-4$ ...	8·5 8·7	8·6	Very slowly diminishing.
30·3		60	$h-2$; $g+2$ ...	10·3 10·2	10·25	a 3 or 4 tenths $>b$ and more ruddy. h 4 or 5 tenths $>k$.
1864. Jan. 5		60	$l-1$	11·3	11·3	h certainly 3 or 4 $>k$. b very ruddy and $<a$.
May 16		60	11·0 mag. est.	11·0 est.	11·0	
June 4		102	$m+5$; $=n$ ...	12·4 12·6	12·5	
8		102	$n+2$... ...	12·8	12·8	
13		...	13·0 est. ...	13·0 est.	13·0	a 4 tenths $>b$. a ruddy.
July 4·5		60 173	$l+3$; $m-1$...	11·7 11·8	11·75	Past minimum.
5·5		...	$l+1+2$; $m-2-3$	11·5 11·6 11·7 11·6	11·6	$b=a+2$.
Aug. 1·5		60 173	$c-1$	8·2	8·2	Fine evening.
2		60 173	$c-2$	8·1	8·1	$b=a+1$.
6·3		60 173	$a+6$; $c-6$ ...	7·7 7·7	7·7	7·7 est. $b=a$. $=a+1$?
12·3		60	$a+5$; $c-7$ ...	7·6 7·6	7·6	$b=a$ ($=a-1$?). R pale yellow.
Sept. 22·3		60	$d+1$; $e-3$; $f-4$	9·2 9·2 9·3	9·2	Obs. interrupted by clouds. Not good.
23·3		60	$d+1$; $e-2-3$; $f-5$	9·2 9·3 9·2 9·2	9·2	b very decidedly $<a$. $=a+4$?
24·3		60	$d+1$; $e-2$ ...	9·2 9·3	9·25	a 7·0 7·1. $b=7·3$ 7·4 photom. a fuller coloured than b. A fine night.
26·3		60	$d+3+4$ $e-1$; $f-3$	9·4 9·5 9·4 9·4	9·4	$b=a+3$.
27·3		60	$=e$; $f-2$ ...	9·5 9·5	9·5	$b=a+2$.
29·3		60	$f-1$	9·6	9·6	$b=a+2$.
Oct. 3·3		60	$f+2+3$; $=g$	9·9 10·0 10·0	10·0	$b=a+1$? Wind east. Clear, but driving clouds.
Nov. 3·3		102	$n+5$ (13·0 est.)	13·1	13·1	Obsn. among clouds. Obs. doubtful, $b=a$? a much deeper in colour, ruddy orange.
26·3		60	$f+4$; $g+2$; $h-2$	10·1 10·2 10·3	10·2	$b=a$. $=a+1$?

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1864.	h m					
Dec. 1·3		60	$f-1$	9·6	9·6	
12·3		60	$c+5$; $d-1$ ...	8·8 9·0	8·9	Clouds came up.
17·3		60	$c+3$; $d-5$ ...	8·6 8·6	8·6	
1865.						
Jan. 4·3		60	$b+4$; $c-6$ ...	7·8 7·7	7·75	$b=a+3$; *R* rather ruddy?
7·3		60	$a+5+6$; $b+3+4$	7·6 7·7 7·7 7·8	7·7	$b=a+3+4$. *R* ruddy.
17·3		60	$a+10$; $b+8$; $c-3$	8·1 8·1 8·0	8·1	$b=a+2$; 7h past meridian.
20·3		60	$a+10$; $c-3$	8·1 8·0	8·05	$b=a+2$. 6h past meridian. *R* ruddy.
21·3		60	$a+10$; $c-3$ ...	8·1 8·0	8·05	$b=a+3+4$; *R* ruddy.
28·3		60	$=c$	8·3	8·3	$b=a+2$; *R* ruddy.
Feb. 10·25		60	$=f$	9·7	9·7	6h 30m – 7h past meridian, almost lost in twilight. Obsn. not very good.
Apr. 22·5		60	$d+2$; $e-2$ ...	9·3 9·3	9·3	$b=a+2$. 7h from meridian. Bad definition, but clear; wind N.E.
24·5		60	$d+2$; $e-2$ ...	9·3 9·3	9·3	7h from meridian. Pretty clear.
29·5		60	$d-1-2$ ...	9·0 8·9	8·95	$a\ 3>b$. Far from meridian.
May 15·5		60	$c-2-3$ ...	8·1 8·0	8·05	8·1 photometric measd. $b=a+1$.
22·5		60	$a+7$; $c-5$ ...	7·8 7·8	7·8	Slightly ruddy? $b=a+4$.
24·5		60	$a+7$; $c-5$ ...	7·8 7·8	7·8	$b=a+4$. *R* ruddy?
June 6·5		60	$c-2$	8·1	8·1	$b=a+1+2$.
19·5		60	$d-1$; $c+6$; $f-7$	9·0 8·9 9·0	9·0	Past maximum.
27·5		60	$d+3$; $e-1$; $f-2$	9·4 9·4 9·5	9·4	$b=a+3+4$.
July 3		60	$f+1$; $g-1$ ...	9·8 9·9	9·85	
11·4		60	$h+3$; $k-1$; $l-4$	10·8 10·8 11·0	10·9	
19·5		60	$l+2$; $m-1$ ...	11·6 11·8	11·7	$b=a+2$?
26·4		60	$m+4$; $n-2$ ...	12·3 12·4	12·35	
28·5		60 102	$m+4+5$; $n-3$	12·3 12·4 12·3	12·3	$b=a+2$. Both stars orange ruddy.
Aug. 1·4		191	$=n$	12·6	12·6	
9·4		191	$n+1+2$ ...	12·7 12·8	12·75	$b=a+2$.
14·4		...	$m-0-1$; $l+4+5$	11·9 11·8 11·8 11·9	11·85	$b=a+1+2$.
18·4		60	$k+3$; $l-1-2$	11·2 11·3 11·2	11·2	Past minimum.
22·4		60	$g+1$; $h-4$ ...	10·1 10·1	10·1	Evidently increasing.
24·4		60	$e+2$; $=f$; $g-3$	9·7 9·7 9·7	9·7	Rapidly gaining light.
30·4		60	$e+1$; $f-1$ ...	9·6 9·6	9·6	

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1865. Sept. 7·4	h m	60	$c+6$; $d-2-3$; $e-6-7$	8·9 8·9 8·8 8·9 8·8	8·9	
12·3		60	$c+5$; $d-3$ ...	8·8 8·8	8·8	Ruddy.
14·3		60	$c+2+3$; $d-5-6$	8·5 8·6 8·6 8·5	8·55	Decidedly ruddy.
18·3		60	$c-3$	8·0	8·0	
22·4		60	$a+6$; $c-6$ ...	7·7 7·7	7·7	Ruddy. $b=a+2$.
Oct. 3·4		60	$a+4$; $c-8$ ...	7·5 7·5	7·5	Ruddy. $b=a+1$.
4·5		70	$a+4+5$; $c-8$	7·5 7·6 7·5	7·5	$b=a+3$?
13·3		70	$a+5$; $c-7$ ...	7·6 7·6	7·6	Ruddy.
20·3		70	$a+7+8$; $c-4-5$	7·8 7·9 7·9 7·8	7·85	Ruddy. $b=a+3$.
Nov. 1·3		60	$c+5$; $d-2-3$; $e-7$	8·8 8·9 8·8 8·8	8·8	$b=a+2+3$.
3·3		70	$=d$; $c+8$; $f-6$; $e-4$	9·1 9·1 9·1 9·1	9·1	$b=a+1+2$.
13·3		60	$f+4$; $g+1$; $h-3$	10·1 10·1 10·2	10·1	$b=a+0+1$.
15·3		...	$g+3$; $h-2$ ...	10·3 10·3	10·3	$b=a+2$.
18·3		70	$k+1$; $l-3$ ...	11·0 11·1	11·05	
24·3		70	$l+3$	11·7	11·7	Among clouds. A glimpse only; obs. doubtful.
29·3		191	$n+0+1$ ...	12·6 12·7	12·65	
Dec. 1·3		191	$n+3+4$ ...	12·9 13·0	12·95	13 mag. estimated.
12·3		191	... ...	13·6 13·7 est.	13·6	Considerably less than m or n. Glimpsed between clouds.
14·3		191	. ...	13·6 13·7 est.	13·6	Considerably less than n.
30·3		191	$m+3$; $n-4$ ...	12·2 12·2	12·2	Observation doubtful. Clouds.
1866 Jan. 6·3		191	$l+2$; $m-3$ ...	11·6 11·6	11·6	
9·4		...	$g+8$; $=k$; $l-6$	10·8 10·9 10·8	10·8	$b=a+3$.
12·3		70	$g+3$; $h-2$ ...	10·3 10·3	10·3	Observation rather doubtful.
15·3		70	$=g$	10·0	10·0	Obs. interrupted by clouds.
Apr. 17·5		70	... ...	12·6 ± ?	12·6	$6\frac{3}{4}^h$ from meridn. Seen by glimpses only.
May 4·5		70	... ...	13·0 13·2	13·1	6^h from meridn. Glimpsed. m and n fairly seen.
16·5		70 102	$m+5$ ...	12·4	12·4	
19·5		70	$m+1+2$ ...	12·0 12·1	12·05	5^h from meridn.
23·5		70	$l+1+2$; $m-3-4$	11·5 11·6 11·6 11·5	11·55	Past. min. [Min. 1866. May 3 ?]
June 7·5		...	$=d$; $f-6$ ...	9·1 9·1	9·1	
14·4		70	$c+4$; $d-4$ ...	8·7 8·7	8·7	Slightly ruddy.
22·4		70	$c-2-3$ ...	8·1 8·0	8·05	$b=a$.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1866.	h m					
June 25·4		...	$a+7$; $c-5$ ...	7·8 7·8	7·8	
July 9·4		70	$a+6$; $c-6$ ...	7·7 7·7	7·7	Decidedly ruddy. $b=a+4$.
10·5		70	$a+5+6$ ...	7·6 7·7	7·65	$b=a+4+5$. *R* ruddy.
14·4		70	$a+6$; $c-6$ ...	7·7 7·7	7·7	$b=a+4+5$. *R* decidedly ruddy.
19·4		70	$a+7+8$; $c-4-5$	7·8 7·9 7·9 7·8	7·85	Decidedly ruddy. Obs. much interrupted by clouds.
20·4		70	$a+9$; $c-3$ ...	8·0 8·0	8·0	Decidedly ruddy. $b=a+3+4$. *a* and *b* both have a ruddy cast.
Aug. 3·5		70	$c+4$; $d-4$ ...	8·7 8·7	8·7	$b=a+4+5$. *R* ruddy.
9·4		...	$=d$; $e-4$; $f-5$	9·1 9·1 9·2	9·1	$b=a+4$.
16·4		70	$f+1+2$; $g-3$	9·8 9·9 9·7	9·8	$b=a+2+3$. *R* slightly ruddy?
21·4		70	$f+7$; $h-1$ ...	10·4 10·4	10·4	
27·4		173	$l+3$; $m-2$...	11·7 11·7	11·7	
31·5		173	$m+1$; $n-5$	12·0 12·1	12·05	
Sept. 11·3		89	$m+3$; $n-3-4$	12·2 12·3 12·2	12·2	Clouds troublesome.
14·4		173	$m+5$; $n-2$...	12·4 12·4	12·4	Sky clear. Fair observation.
24·4		173	$m+0+1$; $n-6-7$	11·9 12·0 12·0 11·9	11·95	Past min.? Bright moonlight.
Oct. 8·3		70	$f+1$; $g-2$ ...	9·8 9·8	9·8	
13·3		70	$d+3+4$; $=e$; $f-2$	9·4 9·5 9·5 9·5	9·5	$b=a+2$. Air still. Sky very hazy. Defin. bad. Wind N?
22·3		70	$c+4$; $d-4$ ...	8·7 8·7	8·7	
Nov. 3·3		70	$a+7$; $c-5$ ...	7·8 7·8	7·8	Among clouds. Obs. doubtful.
6·3		70	$a+2$! ...	7·3	7·3	$b=a-1$. Whiter in colour than *a*.
13·3		70	$a+0+1$ ...	7·1 7·2	7·15	$b=a$. *R* 7·1 7·2 gauged.
19·3		70	$a+1$ ...	7·2	7·2	$b=a-1$? *b* whitish yellow. *a* ruddy. *R* very decidedly ruddy.
20·4		70	$a+1$ ...	7·2	7·2	$b=a-1$. *R* decidedly ruddy, very similar in colour to *a*. *b whitish* yellow as compared with *a*. (A very bright maximum.)
27·3		70	$a+5$; $c-7$...	7·6 7·6	7·6	*a* $2>b$. *a* fine ruddy. *R* decidedly ruddy; past maximum.
Dec. 7·3		70	$a+8+9$; $c-3$	7·9 8·0 8·0	8·0	Very decidedly ruddy. *b* rather dull and 2 or 3 tenths less than *a*.
10·4		70	$c-2-3$ ...	8·1 8·0	8·05	Decidedly red. 6^h past meridian.
19·3		70	$c+5$; $d-2$...	8·8 8·9	8·85	Ruddy.
26·25		70	$e+1+2$; $=f$	9·6 9·7 9·7	9·7	Decidedly ruddy.
30·25		70	$g+2$; $h-3$...	10·2 10·2	10·2	
1867. Jan. 4·3		70 89	$=k$; $l-4$ ...	10·9 11·0	10·95	
8·3		70	$=m$	11·9	11·9	
11·25		70 89	$m+3$; $n-4$	12·2 12·2	12·2	*a* fine ruddy, 2 or $3>b$.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867. Jan. 12	h m 7 0	89	4 or 5 tenths $< m$	12·3 12·4	12·35	Obsn. doubtful. Hazy.
14	6 25	89	$n+2+3$ ...	12·8 12·9	12·85	Clear, cold, snow on ground.
Apr. 29	12 30	70	$=e$; $f-2$ ...	9·5 9·5	9·5	a 1 or 2 $> b$. Clear sky.
May 3	12 20	70	$=f$	9·7	9·7	A careful comparison.
7	13 —	70	$f+2$; $g-1$...	9·9 9·9	9·9	R decreasing.
24	13 0	89	$=m$	11·9	11·9	Moon rising. Sky clear and definition good.
June 1	14 0	191	$m+2$; $n-5$	12·1 12·1	12·1	
10	12 40	191	... ...	13·3 13·5 est.	13·4	Considerably less than n.
26	12 30	89	$m+2$; $n-5$	12·1 12·1	12 1	a some tenths (3 or 4) $> b$.
28	11 —	89	$l+5$; $m-0-1$	11·9 11·9 11·8	11·9	a a few tenths $> b$. a fine orange ruddy.
July 4	11 —	70 89	$g+6$; $h+1$; $k-3$; $l-8$	10·6 10·6 10·6 10·6	10·6	5-inch aperture.
5	12 0	70	$f+5$; $g+3$; $h-2$	10·2 10·3 10·3	10·3	5 inch aperture. a 3 or 4 $> b$.
9	11 —	70	$=f$; $g-3$ ...	9·7 9·7	9·7	5-inch aperture; clear; a 3 or 4 $> b$.
16	11 30	70	$d+3$; $e-1$; $f-3$	9·4 9·4 9·4	9·4	5-inch aperture. R slightly ruddy? Bright moonlight. a 4 $> b$.
27	11 —	70	$c+3$; $d-5$...	8·6 8·6	8·6	Ruddy.
31	10 +	70	$c+1+2$; $d-6-7$	8·4 8·5 8·5 8·4	8·45	5-inch aperture.
Aug. 2	11 30	70	$a+10$; $c-2$; $d-10$	8 1 8·1 8·1	8·1	Decidedly ruddy. 5-inch aperture. a 4 $> b$.
9	10 40	70	$a+7+8$; $c-4$	7 8 7·9 7 9	7·9	Slightly ruddy. 5-inch aperture. a 2 or 3 $> b$.
12	10 50	70	$a+7+8$; $c-4$	7·8 7·9 7·9	7·9	Ruddy? 5-inch aperture.
20	8 40	70	$a+7+6$; $c-5$	7·8 7·7 7·8	7·8	Slightly, but decidedly ruddy. a 2 or 3 $> b$.
21	13 30	70	$a+7$; $c-6$...	7·8 7 7	7·75	Decidedly ruddy.
23	10 40	70	$a+7+8$; $c-4-5$	7·8 7·9 7·9 7·8	7·85	Among clouds.
Sept. 3	10 20	70	$c+1$; $d-7$...	8·4 8·4	8·4	Careful estimate, certainly not equal to c. Dull ruddy.
4	8 30	70	$c+1+2$; $d-6-7$	8·4 8·5 8·5 8·4	8·45	Certainly ruddy, I think I may say certainly *red*. Rather dull hue. 5-inch aperture.
10	10 10	70	$c+6$; $d-2$...	8·9 8·9	8·9	4-inch aperture. Bright moonlight.
Oct. 5	6 45	89	$l+3+4$; $m-2$	11·7 11·8 11·7	11·7	Tolerably clear.
17	9 45	89 191	$n+2$ ...	12·8	12·8	Decidedly less than n. Est. abt. 13 mag. A bright 13 mag.
19	8 —	191	$n+4$ ...	13·0	13·0	Certainly less than n.
Nov. 2	9 —	191	$n+9$ ...	13·5	13·5	13·5 est. Consid. less than n. Certainly not brighter than 13 5. m and n well seen, as also R. $b=a+3+4$.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1867.	h m					
Nov. 5	7 45	258	$n+7$ ...	13·3	13·3	13·3 ± est.
13	7 40	191	$l+4$; $m-1-2$	11·8 11·8 11·7	11·8	Brightening up.
23	7 45	89	$f+4$; $h-4$...	10·1 10·1	10·1	Fair obs. Full aperture.
Dec. 2	6 30	89	$d+3$; $e-1$; $f-3$	9·4 9·4 9·4	9·4	Defn. bad. Aperture reduced to 5-inch.
4	9 0	70	$d+2$; $e-2-3$	9·3 9·3 9·2	9·3	5h past meridian.
7	7 40	70	$c+7$; $d-1$; $f-7$	9·0 9·0 9·0	9·0	Slightly ruddy? Full aperture.
12	6 30	70	$c+2$; $d-6$...	8·5 8·5	8·5	Slightly ruddy orange. 4-inch aperture.
18	7 30	70	$=c$	8·3	8·3	Careful comparison.
20	7 0	70	$c-2-3$ ...	8·1 8·0	8·05	Among haze. Obsn. rather doubtful.
26	7 0	70	$a+9$; $c-3-4$	8·0 8·0 7·9	8·0	Orange red.
1868. Jan. 20	6 0	70	$c+4$; $d-4$; $f-10$	8·7 8·7 8·7	8·7	5h past meridian. Stars rather confused. *R* very slightly ruddy ? ?
Feb. 6	6 45	70	$f+5\pm$ ...	10·2 ±	10·2 ±	Bright moonlight and star $6\frac{3}{4}^h$ fr. meridian. Certainly seen, but with difficulty. Some tenths less than *f*. The estimate of magnitude is necessarily uncertain.
May 14	11 30	70	$a+5$; $c-7$...	7·6 7·6	7·6	Doubtful. 6h from meridian. *R* slightly ruddy. 4-inch aperture.
18	11 10	70	$a+5$; $c-7$...	7·6 7·6	7·6	Decidedly ruddy. 6h from meridian. Wind E. Defn. bad. A very warm day.
23	11 0	70	$a+8$; $c-4$...	7·9 7·9	7·9	*R* ruddy, very decidedly. $b=a+5$.
26	11 15	70	$a+9$; $c-3$...	8·0 8·0	8·0	Slightly ruddy? 4-inch aperture.
27	11 45	70	$a+9$; $c-3$...	8·0 8·0	8·0	Slightly ruddy.
June 5	11 0	70	$c+1$; $d-7$...	8·4 8·4	8·4	Certainly ruddy.
13	10 40	70	$d+2$; $e-2$; $f-4$	9·3 9·3 9·3	9·3	Orange ruddy.
17	11 15	70	$e+1$; $f-1$...	9·6 9·6	9·6	Slight orange tint?
23	11 45	70 89	$g+5$; $=h$; $k-4$	10·5 10·5 10·5	10·5	
29	11 15	89	$l+3$; $m-2$...	11·7 11·7	11·7	
July 13	10 30	191	... ...	13·0 est.	13·0 est.	Careful estimation.
20	10 45	89	$m+8$; $n+1$	12·7 12·7	12·7	*a* full orange red, a few tenths > *b* (coppery ruddy).
25	10 20	191	$m+6+7$; $=n$	12·5 12·6 12·6	12·6	Wind from N.N.E. and definition execrable.
Aug. 3	10 15	89 191	$l+3$; $m-2$	11·7 11·7	11·7	Bright moonlight. Obsn. a little doubtful.
8	10 30	191	$=l$	11·4	11·4	Clear at intervals. Flying clouds about.
10	12 10 ±	70	$h+4$; $=k$; $l-5$	10·9 10·9 10·9	10·9	Decidedly brighter than on the 8th.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1868.	h m					
Aug. 21	10 30	70	$=f$	9·7	9·7	Careful estimation, but sky hazy.
Sept. 5	8 30	70	$c+4$; $d-4$...	8·7 8·7	8·7	Slightly orange red? A careful comparison. Fine.
30	6 50	70	$a+9$; $c-3$...	8·0 8·0	8·0	Copper coloured. Moon rising. Just upon full.
Oct. 7	8 0	70	$a+14$; $c+2$; $d-6$	8·5 8·5 8·5	8·5	Orange red. *a* some few tenths > *b*. *a* golden rosy flush. *b* clear pale yellow. Observed with 4-inch aperture.
23	8 0	70	$d+2$; $e-2$; $f-4$	9·3 9·3 9·3	9·3	Decidedly ruddy.
Nov. 2	8 47	70	$f+5$; $g+2$; $h-3$	10·2 10·2 10·2	10·2	Good observation. Sky clear.
5	8 40	70 89 191	$h+4$; $k+0$; $l-5$	10·9 10·9 10·9	10·9	Careful estimate. $b=a+5$.
Dec. 19	7 50	191	$n+1+2$ ...	12·7 12·8	12·75	Fair observation.
23	7 25	70 191	$l+3$; $m-2$...	11·7 11·7	11·7	Certainly brighter than when last observed. $b=a+4+5$.
30	9 0	89	$g+3$; $h-2$...	10·3 10·3	10·3	$6\frac{1}{2}^h$ past meridian, and moonlight.
1869. Jan. 5	7 30	70 191	$e+2$; $=f$; $g-3$	9·7 9·7 9·7	9·7	$b=a+4$; *a* bright golden with rosy flush, *b* duller than *a*, coppery yellow, *R* orange tint?
Feb. 2	6 5	70	$a+9$; $c-3$...	8·0 8·0	8·0	8·0 est. Fine coppery red. Full twilight. 6^h past meridn.
June 15	10 55	70	$a+5$; $c-7$...	7·6 7·6	7·6	
29	12 30	70	$a+7$; $c-5$...	7·8 7·8	7·8	Orange red.
July 3	10 30	70	$c-2$... ...	8·1	8·1	Coppery red. Decided colour.
10	10 50	70	$=c$?... ...	8·3?	8·3?	5-inch aperture. *R* clear coppery red. I am much mistaken if *d* is not as bright as or brighter than (?) *c*. On re-examination of the field this obsn. refers *not* to *d*, but to the s.p. of two stars marked ξ on my chart.
23	11 28	70	$c+7$; $d-1$; $f-7$	9·0 9·0 9·0	9·0	Decided orange red.
Aug. 6	10 55	89	$f+8$; $=h$; $l-9$	10·5 10·5 10·5	10·5	Careful obs. 5-inch aperture.
12	10 14	89	$k+3$; $l-2$...	11·2 11·2	11·2	Sky clear. Full aperture.
17	10 5	191	$l+1$; $m-4$...	11·5 11·5	11·5	Fair observation. Clear.
24	8 45	191	$l+5$; $=m$; $n-7$	11·9 11·9 11·9	11·9	Well seen. Good obsn.
26	11 25	191	$m+3$; $n-4$	12·2 12·2	12·2	Good observation.
Sept. 20	10 57	191	$h+5$; $l-4$...	11·0 11·0	11·0	Pretty good observation.
Oct. 9	7 30	70	$=g$	10·0	10·0	Good obsn.
26	7 12	70	$a+7$; $c-5$...	7·8 7·8	7·8	Steady. Ruddy orange. $a=b+3$.
Nov. 4	10 25	70	$a+6$; $c-6$...	7·7 7·7	7·7	3-inch aperture. Coppery red. *b* very nearly $=a$. Slightly less?
6	8 25	70	$a+6$; $c-6$...	7·7 7·7	7·7	Ruddy.
10	8 55	70	$a+6$; $c-6$...	7·7 7·7	7·7	Clear coppery red. $b=a+3+4$?

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1869.	h m					
Nov. 11	7 15	70	$a+6$; $c-6$...	7·7 7·7	7·7	Copper coloured. $b=a+3\pm$.
20	6 50	70	$a+9$; $c-3$...	8·0 8·0	8·0	Coppery red. From careful obsn. with full aperture and with one of 3·7 inches.
28	8 35	70	$c+4$; $d-4$...	8·7 8·7	8·7	Clear coppery red. Clear, but bad definition. Strong breeze from N.W.
30	7 40	70	$c+5$; $d-3$...	8·8 8·8	8·8	Decidedly ruddy.
Dec. 24	6 30	191	$m+2$; $n-5$	12·1 12·1	12·1	Careful comparison, but definition confused.
1870. Jan. 5	7 35	89	... ...	$12\frac{1}{2}$ est.	12·5	Not well seen. Far from meridian and indistinct.
10	6 50	89 191	Not seen ...	Under 12	< 12·0	m seen. Hazy, and star 5^h past meridian.
Apr. 25	12 15	70	$g+3$; $h-2$...	10·3 10·3	10·3	10·3 est. White. Still and clear.
May 2	12 0	89	$l+1$; $m-4$...	11·5 11·5	11·5	Obs. a little uncertain. Star 6^h from meridn. Wind N.E. and air cold.
7	11 15	191	$l+4$; $m-1$...	11·8 11·8	11·8	Vision a little confused.
June 6	11 10	89 191	... ...	13·0? est.	13·0 est.	Not well observed. Far from meridn., and haze. m and n seen.
20	12 10	89	$l+5$; $=m$ ...	11·9 11·9	11·9	Clear. Fair obs.
Oct. 15	8 30	89	$n+6$... ...	13·2	13·2	I think the star has a pale bluish tinge. Well seen, $13\frac{1}{4}$ est.
17	9 0	89	$n+6$... ...	13·2	13·2	$13\frac{1}{4}$ est. Bright, but bad definition.
24	11 0	89 191	$n+9$... ...	13·5	13·5	Fainter, I think, than on the 17th. $13\frac{1}{2}$ est. b 4 or $5<a$.
26	7 15	191	... ...	13·5	13·5 est.	Careful estimation. Much less than n.
Dec. 29	6 45	70	$c-1$... ...	8·2	8·2	$b=a+5$. R white or very pale yellow? Moonlight.
1871. Jan. 5	8 0	70	$c+3$; $d-5$...	8·6 8·6	8·6	6^h past meridn. and obs. doubtful. Hazy and moonlight.
12	6 40	70	$c+7$; $d-1$...	9·0 9·0	9·0	Good observation. Still and clear.
May 17	12 20	70	... ...	...	7·8 est.	Ruddy orange. Very decided tint.
22	12 15	70	$c-5$... ...	7·8	7·8	7·8 est. Orange red. Decided hue.
June 5	10 50	70	$d+3$; $f-3$...	9·4 9·4	9·4	Slightly ruddy.
26	10 50	156	$m+5$ ...	12·4	12·4	$12\frac{1}{2}$ est.
28	11 40	115	$n+2$... ...	12·8	12·8	$12\frac{3}{4}$ 13 est.
July 22	10 55	115	... ...	13·5 13·7 est.	13·6 est.	About one mag. less than n.
29	10 20	115	Glimpsed ...	13·5?	13·5?	Moonlight and haze.
Aug. 15	11 12	70	$=l$	11·4	11·4	Clear sky.
31	10 40	70	$=e$; $f-2$ ...	9·5 9·5	9·5	Slightly ruddy? Bright moonlight and light clouds. Still.
Sept. 9	10 45	70	$c+5$; $d-3$...	8·8 8·8	8·8	Ruddy.
20	10 35	70	$c+0+1$; $d-8-7$	8·3 8·4 8·3 8·4	8·35	Certainly ruddy.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1871. Oct. 3	h m 8 30	70	$c+6+7$; $d-1-2$	8·9 9·0 9·0 8·9	8·95	Hurried observation, caught among clouds. *R certainly much less than c.* It must be past maximum.
9	11 0	70 115	$c+6$; $d-2$; $f-8$	8·9 8·9 8·9	8·9	Clear. Careful estimation.
12	11 20	70 115	$=d$; $f-6$ ...	9·1 9·1	9·1	Ruddy.
14	8 0	70	$e+1$; $f-1$ ...	9·6 9·6	9·6	Clear.
23	8 40	115	$f+3$; $=g$ ...	10·0 10·0	10·0	Not *greater than g.*
Nov. 18	6 53	191	$n+7$... ...	13·3	13·3	13–14 est. *m* and *n* well in view.
29	6 45	191	$n+5$... ...	13·1	13·1	A faint 13 mag. est. *a* and *b* nearly equal in mag.
Dec. 4	8 50	191	$n+8$? ...	13·4	13·4	About 13½ mag. est. Observed with difficulty. Cold. Hard white frost. Bad definition and stars at times obliterated by haze. *a* some few tenths > *b*.
29	5 40	70	$e+2$; $f-0-1$	9·7 9·7 9·6	9·7	Slightly ruddy.
1872. Jan. 6	6 50	70	$c+6$; $f-8$...	8·9 8·9	8·9	I do not notice any ruddy tinge. *R* seems *white*. I think *d* is hardly so bright as 9·1.
May 15	11 3	70	$f+1$; $g-2$...	9·8 9·8	9·8	$6\frac{1}{2}^{h}$ from meridn.
21	11 30	70	$d+1$; $f-5$...	9·2 9·2	9·2	*a* and *b* nearly equal. *R* white?
27	12 25	70	$c+6$; $d-2$...	8·9 8·9	8·9	*R* ruddy.
June 13	11 40	70	$c+2$... ...	8·5	8·5	8½ mag. est. Decidedly ruddy. *a* and *b* very nearly equal.
29	11 15	70	$a+11$; $c-1$	8·2 8·2	8·2	Ruddy orange.
July 9	11 0	70	$c+0+1$ ...	8·3 8·4	8·35	Ruddy. Past max.?
20	11 40	70	$c+4$; $d-4$; $f-10$	8·7 8·7 8·7	8·7	Slightly ruddy?
Aug. 27	11 50	115	$n+2$... ...	12·8	12·8	12¾ est.
31	10 45	115	$n+5+6$ ...	13·1 13·2	13·15	13–13½ est.
Sept. 5	8 35	115	$n-1$; $=n$ ...	12·5 12·6	12·55	12½ est.
16	11 5	115	$=l$; $m-5$ ...	11·4 11·4	11·4	Well seen in a moonlit field. 11½ mag. est.
19	10 50	70 89 191	$f+12$; $=h$; $l-5$	10·9 10·9 10·9	10·9	Bright moonlight.
21	10 5	70	$h-1$; $g+4$...	10·4 10·4	10·4	Cold air. Wind getting up. Rather poor definition.
Oct. 7	10 40	70	$c+3$; $d-5$...	8·6 8·6	8·6	Ruddy slightly? $b=a+3$.
9	10 30	70	$c+3$; $f-11$	8·6 8·6	8·6	Decidedly ruddy.
18	8 45	70	$a+9$; $c-3$...	8·0 8·0	8·0	Slightly ruddy? Not so much so as *a* or *b*. Clouds coming up from S.W.
22	9 5	70	$a+8$; $c-4$...	7·9 7·9	7·9	Very slightly ruddy.
28	10 10	70	$a+8$; $c-4$...	7·9 7·9	7·9	Decidedly ruddy. A bright 8 mag. est.
Nov. 7	8 15	70	$a+9$; $c-3$...	8·0 8·0	8·0	Certainly ruddy. Decidedly so. About 8 mag. est.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1872.	h m					
Nov. 12	9 0	70	$a+9$; $c-3$...	8·0 8·0	8·0	Ruddy decidedly.
23	8 20	70	$c+2+1$; $d-6-7$	8·5 8·4 8·5 8·4	8·45	*Ruddy.* Obs. difficult. Stars caught in clear intervals between clouds. *R* very ruddy.
Dec. 4	8 30	70	$c+4$; $d-4$; $f-10$	8·7 8·7 8·7	8·7	Ruddy. Obs. troublesome. Clouds about.
9	8 50	70 115	$c+9$; $d+1$; $e-3$; $f-5$	9·2 9·2 9·2 9·2	9·2	Ruddy slightly. Obs. difficult on account of haze and cloud.
1873.						
Jan. 2	6 30	115 191	$m+4$; $n-3$	12·3 12·3	12·3	A faint 12 mag. est.
21	6 10	191	$m+4+5$; $n-2$	12·3 12·4 12·4	12·4	Clear.
28	6 30	191	$m-2$; $l+3$...	11·7 11·7	11·7	6^h past meridn. Clear. Pretty good observation. About $11\frac{3}{4}$ mag. est.
1876.						
Nov. 16	9 0	70	$c+5$; $d-3$...	8·8 8·8	8·8	Slightly ruddy.
20	7 0	70	$c+6$; $d-2$; $e-6$	8·9 8·9 8·9	8·9	Ruddy.
29	7 20	70	$c+3$; $d-5$...	8·6 8·6	8·6	Bright moonlight. *R* ruddy.
Dec. 22	6 35	70	$c-2$; $a+10$	8·1 8·1	8·1	Ruddy decidedly.
1877.						
Jan. 9	8 0	70 89	$d+4$; $=e$; $f-2$	9·5 9·5 9·5	9·5	$6\frac{1}{2}^h$ past meridian. Past max.
20	6 45	115	$h+5$; $k+1$; $l-4$	11·0 11·0 11·0	11·0	$5\frac{3}{4}^h$ past meridian. Unsteady, 11 mag. est.
26	6 40	115	$=l$	11·4	11·4	6^h past meridian and bright moonlight. Obs. difficult. *R* $11\frac{1}{2}$ mag. est.? (N.B.—In the original entry the light est. stands ($=k$), but obviously this is a mistake for l, as shown by the deduced mag. and by the est. mag.)
30	6 30	115	$m+1$ ...	12·0	12·0	12 mag est.
Apr. 25	12 45	70	$a+5$; $c-7$...	7·6 7·6	7·6	Orange coloured? A bright maximum.
May 2	11 40	70	$a+5$; $c-7$?	7·6 7·6	7·6	$6\frac{1}{2}^h$ fr. meridian and not very clear. Obs. rather doubtful.
4	11 55	70	$a+6+7$; $c-6-5$	7·7 7·8 7·7 7·8	7·75	Ruddy. $6\frac{1}{4}^h$ fr. meridian.
15	12 15	70	$c+2$; $d-6$...	8·5 8·5	8·5	Very decidedly red.
June 9	10 50	70	$f+12$; $h+4$; $=k$; $l-5$	10·9 10·9 10·9 10·9	10·9	5^h from meridian.
20	11 15	191	$=m$?; $l+5$?	11·9 11·9	11·9	Observation difficult, very. Hazy. *R* seen pretty well, and decidedly less by some tenths than l. Apparently about equal to m, which is pretty well seen at times.
23	11 30	191	$l+6$; $m+1$; $n-6$	12·0 12·0 12·0	12·0	12 mag. est.
25	12 0	191	$m+2$; $n-5$	12·1 12·1	12·1	About 12 mag. Well seen.
29	12 10	115	$=n$	12·6	12·6	Clear.
July 7	11 55	115	$=n$	12·6	12·6	
17	11 50	115	$=n$; $n-$? ...	12·6	12·6	Clear, but high wind and bad definition.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1877. July 26	h m 10 30	115	$k+5$; $=l$; $m-5$	11·4 11·4 11·4	11·4	Clear, well seen, but definition not good.
30	11 25	115	$f+8$; $=h$; $k-9$*	10·5 10·5 10·5	10·5	Clear. Good observation.
Aug. 2	11 0	70 115	$f+3$; $=g$ ...	10·0 10·0	10·0	Clear sky.
7	11 30	70	$e+1$; $f-1$ ...	9·6 9·6	9·6	Slightly ruddy?
14	11 5	70	$d+2$; $e-2$ ...	9·3 9·3	9·3	Haze and cloud troublesome.
15	11 5	70	$c+8$; $=d$; $f-6$	9·1 9·1 9·1	9·1	Decidedly ruddy. Obs. in clear intervals between clouds.
17	10 35	70	$d-1$; $\frac{1}{2}(c+f)$	9·0 9·0	9·0	Certainly slightly ruddy.
Sept. 27	10 25	70	$c+3$; $d-5$ ...	8·6 8·6	8·6	Ruddy.
29	10 15	70	$c+4$; $d-4$ ...	8·7 8·7	8·7	Decidedly ruddy.
Oct. 1	9 0	70	$c+5$; $d-3$ ...	8·8 8·8	8·8	*R* decidedly of a ruddy hue.
4	9 0	70	$c+6$; $d-2$ ...	8·9 8·9	8·9	Decidedly ruddy.
9	8 45	70	$d+1$; $e-3$; $f-5$	9·2 9·2 9·2	9·2	Ruddy?
15	11 30	70 115	$=f$	9·7	9·7	Clear. Wind high.
22	11 30	115	$g+6$; $h+1$; $k-3$	10·6 10·6 10·6	10·6	Moonlight.
27	8 25	115	$l+1$; $m-4$ ...	11·5 11·5	11·5	Clear. Bad definition. S.W. wind.
Nov. 14	8 15	70 115	$=n$	12·6	12·6	Clear. Moonlight. Clouds coming up.
19	8 50	115	$n+4+6$ ...	13·0 13·2	13·1	Moonlight, but clear. Bad definition. A gale subsiding.
30	7 35	115	$n+5+7$ ...	13·1 13·3	13·2	A much $<n$ as n is $<m$. A faint 13 mag. est. Obs. interrupted by clouds.
Dec. 6	8 55	115 191	$m+2$; $n-5$	12·1 12·1	12·1	Clear, but bad definition. A rather doubtful obs.
10	6 25	115 191	$m-2$; $l+3$ ...	11·7 11·7	11·7	Clear. Well seen.
12	8 45	115	$k+4$; $l-1$ ...	11·3 11·3	11·3	5^h past meridian. $11\frac{1}{4}$ est.
18	8 30	89	$f+5$; $g+2$; $h-3$	10·2 10·2 10·2	10·2	A doubtful obs. Stars almost lost in haze in a moonlit sky.
24	8 30	70	$d+4$; $=e$; $f-2$	9·5 9·5 9·5	9·5	Clear and cold. Well seen.
27	6 55	70	$c+8$; $=d$; $f-6$	9·1 9·1 9·1	9·1	Ruddy.
1878. Jan. 7	7 30	70	$a+10$; $c-2$; $c-3$	8·1 8·1 8·0	8·1	Clear. $5\frac{1}{2}^h$ from meridian.
28	7 15	70	$a+6$; $c-6$ ...	7·7 7·7	7·7	Very doubtful obs. $6\frac{3}{4}^h$ past meridian.
Feb. 6	7 5	70	$a+8$; $c-4$ ...	7·9 7·9	7·9	Obs. very doubtful as star 7^h past meridian. Slightly ruddy?
May 21	12 5	70	$+5$; $d-3$ ...	8·8 8·8	8·8	Slightly ruddy.

[* 1877 July 30. These figures agree with original observation in the Journal. But $k-9=10·0$ not 10·5. On scrutiny the k in the Journal is apparently written over an l: and $l-9$ would give 10·5. But k is clearly the corrected version; and the concluded magnitude should thus stand as 10·3, the mean of 10·5 10·5 10·0.—Ed.]

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean. Mag.	Remarks.
1878. May 25	h m 11 25	70	$c+2$; $d-6$...	8·5 8·5	8·5	Decidedly ruddy. Certainly brighter than on the 21st.
31	11 0	70	$c-2$... ...	8·1	8·1	Ruddy. Barely 8 mag. est.
June 6	11 50	70	$c-3-2$; $a+10+9$	8·0 8·1 8·1 8·0	8·05	Yellow. Not ruddy? Hazy.
12	10 50	70	$a+10$; $c-2$; $d-10$	8·1 8·1 8·1	8·1	Ruddy yellow. Clear. Moonlight.
20	11 35	70	$a+10$; $c-2$...	8·1 8·1	8·1	Orange tint.
25	12 0	70	$c-0-1$? ...	8·3 8·2	8·25	In finder certainly not so bright as *c*. Orange red.
July 13	11 25	70 115	$d+3$; $e-1$; $f-3$	9·4 9·4 9·4	9·4	Decidedly ruddy.
19	11 20	70	$f+3$; $g-3$ ...	10·0 9·7	9·85	10·0 est. [Light ests. as in *Journal*, but qu. some mistake?]
30	11 0	115	$l+1$; $m-4$...	11·5 11·5	11·5	Clear.
Aug. 1	12 30	115	$l+2$; $m-3$...	11·6 11·6	11·6	A clear sky.
8	11 7	115	$m+1$; $n-6$	12·0 12·0	12·0	Clear.
17	11 0	115	$m+4$; $n-3$	12·3 12·3	12·3	Clear sky.
Oct. 12	9 0	70	$a+6$; $c-6$...	7·7 7·7	7·7	Ruddy yellow. Bright moonlight.
14	11 30	70	$a+4$; $c-8$...	7·5 7·5	7·5	Decidedly ruddy. Moonlight and east wind.
24	8 40	70	$a+2$; $c-10$	7·3 7·3	7·3	Ruddy orange.
Nov. 1	8 45	70	$a+5$; $c-7$...	7·6 7·6	7·6	Ruddy orange.
7	8 10	70	$a+7$; $c-5$...	7·8 7·8	7·8	Ruddy orange.
16	7 12	70	$c+0+1$; $d-8$	8·3 8·4 8·3	8·3	Decidedly ruddy.
1879. June 9	11 20	115	$m+5$; $n-2$	12·4 12·4	12·4	About 12½ est.
July 23	10 35	70	$c+4$; $d-4$...	8·7 8·7	8·7	Ruddy. Obs. difficult and doubtful. Haze and cloud very troublesome.
24	11 50	70	$a+12$; $=c$...	8·3 8·3	8·3	Yellowish. Not ruddy, I think.
29	9 30	70	$c-0-1$? ...	8·3 8·2	8·25	Orange colour. Clouds troublesome. In finder *not* $>c$.
Aug. 6	10 0	70	$=c$; $d-8$ ...	8·3 8·3	8·3	Ruddy. Qu. at times barely equal *c*?
11	10 50	60	$c+3$; $d-5$...	8·6 8·6	8·6	Ruddy.
25	10 0	70	$c+10$; $d+2+1$; $e-2$; $f-4$	9·3 9·3 9·2 9·3 9·3	9·3	Ruddy? Clear sky. High wind.
30	9 0	70	$d+4$; $=e$; $f-2$	9·5 9·5 9·5	9·5	Slightly ruddy and not sharply defined? Clear sky. Moon near full.
Sept. 1	9 0	70	$e+2$; $=f$ ...	9·7 9·7	9·7	Moon one day past full, and bright.
Oct. 3	10 20	115	$m+4$; $n-3$...	12·3 12·3	12·3	Bad definition. Wind rather high.
6	8 35	191 89	$m+1+2$; $n-6-5$; $l+6$	12·0 12·1 12·0 12·1 12·0	12·0	Clear, but vision disturbed.
11	7 15	115	$l+4$; $m-1$...	11·8 11·8	11·8	Past minimum.
15	9 55	115	$l+4$; $m-1$...	11·8 11·8	11·8	Unchanged since 11th.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1879.	h m					
Nov. 5	7 35	70	$d+1$; $e-3$...	9·2 9·2	9·2	Ruddy slightly? A fine clear sky.
12	8 15	70	$c+4$; $d-4$...	8·7 8·7	8·7	Slightly ruddy?
18	7 30	70	$c+3+4$; $d-4-5$	8·6 8·7 8·7 8·6	8·65	Slightly ruddy?
Dec. 1	10 3	70	$a+7$; $b+2$; $c-5$	7·8 7·5 7·8	7·7	Ruddy.
6	8 10	70	$a+7$; $c-5$...	7·8 7·8	7·8	Ruddy. $b=a+3$. a and b both decidedly ruddy.
8	7 35	70	$a+7$; $c-5$...	7·8 7·8	7·8	Ruddy orange. $b=a+3+4$.
10	9 5	70	$a+7$; $c-5$...	7·8 7·8	7·8	Ruddy orange. A bright 8 mag. est.
16	8 15	70	$a+10$; $c-2$...	8·1 8·1	8·1	Ruddy orange. About 8 mag. est.
26	7 0	70	$c+1+2$; $d-6-7$	8·4 8·5 8·5 8·4	8·45	Orange tint. Bright moonlight. $b=a+3+4$. Slightly ruddy orange. a golden.
1880.						
Jan. 2	7 45	70	$c+7$; $d-1$...	9·0 9·0	9·0	Sky rather hazy.
3	8 30	70	$c+7$; $d-0-1$	9·0 9·1 9·0	9·0	$6\frac{1}{4}^{h}$ past meridian. Clear.
June 7	11 25	115	$l+4$; $m-1$...	11·8 11·8	11·8	
25	11 15	115 191	$n+9+8$ ...	13·5 13·4	13·45	13·5 est.
July 29	11 10	115	$f+6$; $g+3$; $h-2$	10·3 10·3 10·3	10·3	
Aug. 10	11 0	70	$e+1$; $f-1$...	9·6 9·6	9·6	Slightly ruddy?
31	8 55	70	$=d$	9·1	9·1	Distinctly ruddy.
Sept. 29	7 25	70	$c+5$; $d-3$...	8·8 8·8	8·8	Ruddy.
Oct. 11	8 0	70	$d+3$; $e-1$; $f-3$	9·4 9·4 9·4	9·4	Clear. Moonlight. *R* certainly *not* $>d$.
18	7 40	70 115	$g+5$; $=h$; $k-4$	10·5 10·5 10·5	10·5	
23	8 40	115	$=l$; $k+5$; $m-5$	11·4 11·4 11·4	11·4	
Nov. 3	8 5	70 115	$=n$	12·6	12·6	a a fine orange-tinted star. A fine colour.
19	8 20	115	$n+4$?; $+6$?	13·0 13·2	13·1	Clear sky.
25	8 20	115	$=n$; $n+1$?...	12·6 12·7	12·65	
Dec. 4	8 45	115	$h+5$; $l-4$...	11·0 11·0	11·0	11·0 est.
30	7 30	70	$c+5$; $d-3$...	8·8 8·8	8·8	5^{h} past meridn.
1881.						
Jan. 3	6 50	70	$c+3$; $d-5$...	8·6 8·6	8·6	Decidedly of an orange tint.
7	6 48	70	$c-1$... ...	8·2	8·2	Decidedly ruddy.
May 20	10 50	70	$c+5$; $d-3$...	8·8 8·8	8·8	Orange ruddy. Decidedly.
June 23	11 10	70	$c+4$; $d-4$...	8·7 8·7	8·7	Ruddy.
July 4	10 45	70	$=e$; $f-2$ ...	9·5 9·5	9·5	Slightly ruddy.
Aug. 4	10 2	115	$l+4$; $m-1$...	11·8 11·8	11·8	
Sept. 26	7 5	70	$c+5$; $d-3$...	8·8 8·8	8·8	Certainly ruddy.
28	9 33	70	$c+3$; $d-5$...	8·6 8·6	8·6	Very decidedly ruddy.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881.	h m					
Sept. 30	8 33	70	$c+2$; $d-6$ ...	8·5 8·5	8·5	Ruddy.
Oct. 4	9 3	70	$c-4$... ...	7·9	7·9	7·9 gauged (in finder). Ruddy.
15	8 40	70	$a+6$; $c-7$ ...	7·7 7·6	7·65	7·6 gauged. Ruddy.
19	8 40	70	$a+5$; $c-7$ ...	7·6 7·6	7·6	7·6 gauged. Orange ruddy. A full warm colour.
Nov. 15	8 25	70	$c+4$; $d-4$ ...	8·7 8·7	8·7	8·7 gauged. Orange tint.
17	7 20	70	$c+6+5$; $d-2$	8·9 8·8 8·9	8·9	Orange ruddy.
23	9 5	70	$e+0+1$? $d+3$?	9·5 9·6 9·4	9·5	Ruddy.
28	9 0	70	$=f$	9·7	9·7	
Dec. 3	7 16	70	$f+3$; $=g$; $h-5$	10·0 10·0 10·0	10·0	Moonlight and cloudy haze.
8	7 24	115	$k+3$; $l-2$ ...	11·2 11·2	11·2	A little hazy at times.
13	7 30	115	$l+4$; $m-1$? $=m$?	11·8 11·8 11·9	11·8	Little, if at all, brighter than m.
23	7 5	115	$n+4$... ...	13·0	13·0	About 13 mag. est.
29	6 58	115 191	$n+4$... ...	13·0	13·0	About 13 mag est.
1882. Jan. 4	6 35	115	Glimpsed 13 mag.	...	13·0	
7	6 40	115	...	13 ±	13 ±	
June 15	10 40	115	$f+1$; $g-2$ ...	9·8 9·8	9·8	$b=a+3$; a ruddy.
July 24	10 50	70	$c-2$... ...	8·1	8·1	Ruddy. 8·1 8·2 mag.
Aug. 3	10 45	70	$=c$	8·3	8·3	8·3 gauged.
9	10 20	115 70	$c+3$; $d-5$ ...	8 6 8·6	8·6	Past maximum ?
Oct. 2	8 0	115	$n+4$... ...	13·0	13·0	Several tenths $< n$.
23	8 0	89	$=h$	10·5	10·5	Obs. a little doubtful. $=\frac{1}{2}(g+k)\pm$.
25	9 0	70 115	$f+3$; $h-5$ ...	10·0 10·0	10·0	Bright moonlight.
Nov. 9	8 45	70	$c+6$; $d-2$...	8·9 8·9	8·9	Decidedly ruddy.
17	7 5	70	$c-0-1$ ...	8·3 8·2	8·25	Ruddy.
28	6 10	110 60	$c-0-1$ ...	8·3 8·2	8·25	Ruddy.
Dec. 4	7 15	70	$c-2$... ...	8·1	8·1	Ruddy.
19	8 47	70	$=c$? $c-1$?...	8·3 8·2?	8·25?	$5\frac{1}{2}^h$ past meridn., but fairly clear.
1883. June 15	11 15	115	$n+3+4$ ...	12·9 13·0	12·95	Pretty well seen in clear intervals between clouds.
30	11 12	115	$n+4$... ...	13·0	13·0	Not brighter than 13, I think.
July 13	10 50	115	$m+3$; $n-4$...	12·2 12·2	12·2	Slightly hazy? Reminding one of *U Geminorum* in appearance?
23	10 42	115	$l+3$; $m-2$...	11·7 11·7	11·7	A hurried glimpse between clouds. $11\frac{3}{4}$ est.
28	10 13	70	$l+1$	11·5	11·5	
Aug. 21	9 0	70	$=d$	9·1	9·1	

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1883.	h m					
Oct. 2	7 40	70	$=f$	9·7	9·7	
22	8 40	115	$m+3$; $n-4$...	12·2 12·2	12·2	
Nov. 10	7 10	115	$=n$	12·6	12·6	Moonlight and haze.
17	7 35	115	$n+3+4$ ...	12·9 13·0	12·95	
26	7 45	115	$l+4$; $m-1$...	11·8 11·8	11·8	
Dec. 6	8 10	115	$f+5$; $g+2$; $h-3$	10·2 10·2 10·2	10·2	
21	7 20	70	$=d$	9·1	9·1	Slightly ruddy?
1884. June 30	11 15	115	$=e$	9·5	9·5	Orange ruddy.
July 17	11 25	70	$f+6$; $h-2$...	10·3 10·3	10·3	
Aug. 1	10 51	70	$l+4$; $m-1$...	11·8 11·8	11·8	
22	9 45	115	$l+1$; $m-4$...	11·5 11·5	11·5	Very decidedly brighter than *m*.
Oct. 4	10 0	70	$c-2$... ...	8·1	8·1	Very ruddy.
13	9 55	70	$=b$; $c-8$ ...	7·5 7·5	7·5	7½ est. Decidedly red.
21	8 45	70	$a+6$; $c-6$; $b+3$	7·7 7·7 7·7	7·7	*b* 7·4. *R* ruddy orange. (Clouds coming over. A cloudy sky later on.)
24	9 10	70	$a+6$; $c-6$...	7·7 7·7	7·7	Orange tint. *a* ruddy. $b=a+4$, 7·5
28	8 57	70	$a+7$; $c-4$...	7·8 7·9	7·85	7·8· 7·9 gauged. Ruddy.
Nov. 7	8 47	70	$c+2$... ...	8·5	8·5	Ruddy orange.
15	8 8	70	$c+8$; $=d$; $f-6$	9·1 9·1 9·1	9·1	Ruddy orange tint. Decided hue.
19	8 10	70	$d+4$; $=e$; $f-2$	9·5 9·5 9·5	9·5	Ruddy.
28	8 12	70 115	$=h$; $k-4$; $f+8$	10·5 10·5 10·5	10·5	
Dec. 4	8 12	115	$l+3$; $m-2$...	11·7 11·7	11·7	High wind, almost a gale. Shakes telescope at times.
9	7 33	115	$m+4$; $n-3$	12·3 12·3	12·3	
15	8 0	110	$n+6$... ...	13·2	13·2	13–13½ est.
1885. Jan. 7	6 8	191	$n+7$... ...	13·3	13·3	Glimpsed. 13·3 est. *m* and *n* well seen.
June 1	11 30	110	...	...	12±?	*R* and *m* glimpsed? Rather doubtful. *l* well seen.
17	10 58	115	$f+3$; $=g$ ...	10·0 10·0	10·0	
July 10	11 50	70	$=c$	8·3	8·3	Ruddy.
17	10 40	70	$c-0-1$ ...	8·3 8·2	8·25	Ruddy.
24	10 50	70	$a+11$; $c-1$	8·2 8·2	8·2	Ruddy.
Aug. 10	12 10	70	$c+4$; $d-4$...	8·7 8·7	8·7	Ruddy (so too in finder).
27	10 5	70	$=d$; $c+8$ ...	9·1 9·1	9·1	Ruddy.
Oct. 7	8 35	115	$l+3$; $m-2$...	11·7 11·7	11·7	Half mag. difference between *a* and *b*. *a* 7·1, *b* 7·6, *c* 8·3 gauged.
27	8 0	70	$d+4$; $=e$; $f-2$	9·5 9·5 9·5	9·5	Slightly ruddy. *b* ½ mag. less than *a*. 7·6 gauged, *a* 7·1, *c* 8·3.

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885.	h m					
Nov. 17	7 10	70	$c-3$... ...	8·0	8·0	8·0 gauged. Ruddy orange.
1886.						
June 1	11 15	115	$k+3$; $l-2$ ...	11·2 11·2	11·2	
23	11 15	115	13·5 est. ...	...	13·5	Glimpsed.
30	10 45	115	$n+9$... ...	13·5	13·5	13·5 est. A mag. nearly less than n. Well seen. Clear.
July 5	11 10	115	$n+10$ ...	13·6	13·6	$13\frac{1}{2}$ $13\frac{3}{4}$ est. Clear.
15	11 40	200	Doubtfully glimpsed	13·5 ?	13·5 ?	Doubtful observation. Full Moon and hazy sky.
24	10 40	115	$l+5$; $=m$ ...	11·9 11·9	11·9	Well seen.
Aug. 10	10 15	70 115	$h+3$; $k-1$; $l-6$	10·8 10·8 10·8	10·8	$b=a+3$; yellow; hardly orange.
Sept. 30	8 32	70	$e+1$; $f-1$ ...	9·6 9·6	9·6	Slightly ruddy.
Nov. 16	8 17	115	$n+4$... ...	13·0	13·0	Clear.
29	8 10	115	$m+3$; $n-4$	12·2 12·2	12·2	
Dec. 1	7 40	115	$=m$; $l+5$; $n-7$	11·9 11·9 11·9	11·9	
14	8 0	70 115	$h-2$; $g+3$...	10·3 10·3	10·3	
16	6 40	70	$g+2$; $h-3$...	10·2 10·2	10·2	
18	6 45	70	$f+2$; $g-1$ ...	9·9 9·9	9·9	$b=a+4$.
25	7 35	70	$d+2$; $e-2$ ...	9·3 9·3	9·3	Hazy and 5^h past meridian.
1887.						
June 13	11 35	70	$c-2$... ...	8·1	8·1	Orange ruddy.
30	10 50	70	$=d$	9·1	9·1	Ruddy.
July 18	10 57	70 115	$=l$	11·4	11·4	
Aug. 12	10 25	115	About $=n$ ...	12·6	12·6	
Oct. 1	8 43	70	$d-3$; $c+5$ ...	8·8 8·8	8·8	Ruddy.
17	9 0	70	$a+8$; $c-4$ ...	7·9 7·9	7·9	7·8 7·9 gauged. Ruddy orange. b about 7·5.
31	9 0	[70]	$c-3$... ...	8·0	8·0	
Nov. 30	7 20	70	$f+1$; $g-2$...	9·8 9·8	9·8	Orange ruddy.
Dec. 5	7 15	70	$h+2$; $k-2$...	10·7 10·7	10·7	Sky rather cloudy.
15	7 5	115	$=n$	12·6	12·6	
1888.						
Aug. 13	10 10	70	$c+4$; $d-4$ ...	8·7 8·7	8·7	Orange tint.
Oct. 5	8 50	115	$m+6$; $n-1$	12·5 12·5	12·5	$b=a+3$.
11	10 25	115	$m+6$; $n-1$	12·5 12·5	12·5	
19	8 43	115	$k+2$; $l-3$ ...	11·1 11·1	11·1	Brightening up. $b=a+4$ (7·5).
23	7 53	70	$f+2$; $g-1$ ...	9·9 9·9	9·9	$b=a+2$.
27	7 58	70	$=f$	9·7	9·7	Orange. b ruddy $=a+4$.
Nov. 6	8 0	70	$c+5$; $d-3$ ...	8·8 8·8	8·8	Very ruddy. $b=a+5$.
13	7 0	70	$c+2$; $d-6$...	8·5 8·5	8·5	Ruddy. $b=a+4$.
20	7 30	70	$a+9$; $c-3$ ...	8·0 8·0	8·0	$b=a+4$.
26	7 50	70	$c-5$; $a+7$...	7·8 7·8	7·8	Ruddy. $b=a+5$. Bad definition.

R Vulpeculæ—continued.

Date of Observation	G.M.T.	Power.	Estimated equal to	Deduced Mags.	Mean Mag.	Remarks.
1888.	h m					
Dec. 6	6 55	70	*a*+7 ; *c*−5...	7·8 7·8	7·8	Ruddy. *b* ruddy = *a*+5 ; *R* = *b*+2.
10	6 10	70	*a*+8 ; *c*−4...	7·9 7·9	7·9	*b* ruddy = *a*+5.
12	6 35	70	*a*+9 ; *c*−3...	8·0 8·0	8·0	8·0 gauged. *b* = *a*+3.
26	7 8	70	*a*+10 ; *c*−1−2	8·1 8·2 8·1	8·1	Full ruddy. *b* = *a*+2.
1889.						
Sept. 6	7 45	70	*c*−2... ...	8·1	8·1	Ruddy.
10	9 0	70	*c*−2... ...	8·1	8·1	Ruddy. *b* = *a*+5 ∴ 7·6.
Oct. 21	9 52	115	*l*+1 ; *m*−4...	11·5 11·5	11·5	
25	7 30	115	= *m*	11·9	11·9	
31	8 10	115	*n*+2... ...	12·8	12·8	*b* = *a*+2.
Nov. 2	7 25	110	*n*+2... ...	12·8	12·8	*b* = *a*+3 ; *b* ruddy.
12	7 30	115	*n*+9... ...	13·5	13·5	Nearly a mag. less than *n*. About 13·5 mag. *b* = *a*+3+4.
25	6 20	115	*n*+7... ...	13·3	13·3	As much < *n* as *n* is than *m*. Abt. $13\frac{1}{4}$ $13\frac{1}{2}$ est. *b* orange tint. Half mag. less than *a*. Clear sky. High wind.
30	8 5	115	= *n*	12·6	12·6	Sky rather hazy. *b* = *a*+7 (∴ 7·8). *b* orange ruddy.
Dec. 4	6 40	70 115	*m*+1 ; *n*−6	12·0 12·0	12·0	Brightening up. *b* = *a*+5.
11	6 37	70 115	*f*+8 ; = *h* ; *l*−9	10·5 10·5 10·5	10·5	
12	6 46	70	*f*+5 ; *g*+2 ; *h*−3	10·2 10·2 10·2	10·2	Clouds coming up.
1890.						
Aug. 1	10 0	115	*l*+4 ; *m*−1...	11·8 11·8	11·8	Moonlight and hazy sky.
5	10 53	115	*l*+3 ; *m*−2...	11·7 11·7	11·7	*b* = *a*+3+4.
23	10 44	115	= *m*	11·9	11·9	*b* = *a*+4 ; both stars ruddy (*i.e.* *a* and *b*). *a* has a spectrum with dark bands. Bright spaces? Bright lines??? III. type? Nothing particular about spectrum of *b*.
27	9 56	115	*l*+3 ; *m*−2...	11·7 11·7	11·7	*b* = *a*+4+5, ruddy. *a* golden with rosy flush. Dark bands in spectrum.
30	9 8	115	*l*+1+2 ; *m*−3−4	11·5 11·6 11·6 11·5	11·55	*b* ruddy = *a*+4+5.
Sept. 4	10 10	115	*h*+1 ; *k*−3...	10·6 10·6	10·6	Rapidly brightening up. *b* = *a*+7 *c*−5 ∴ 7·8 ; ruddy.
8	10 7	70	*f*+0+1 ...	9·7 9·8	9·75	Rapidly brightening up. *a* gauged 7·1 7·2, *b* 7·6 7·7, *c* 8·3.
13	8 34	70	*e*+1 ; *f*−1 ...	9·6 9·6	9·6	Not much changed since the 8th.
15	10 24	70	*d*+3 ; *f*−3...	9·4 9·4	9·4	Ruddy.
Oct. 25	8 28	70	*c*−3−4 ; *b*+4+5	8·0 7·9 7·9 8·0	7·95	Decidedly ruddy. *b* = *a*+4 ∴ 7·5. White clouds drifting over. Heavy mist below.
27	8 17	70	*b*+5 ; *c*−3 ...	8·0 8·0	8·0	Ruddy. *b* = 7·5, *c* 8·3.

R Vulpeculæ—continued.

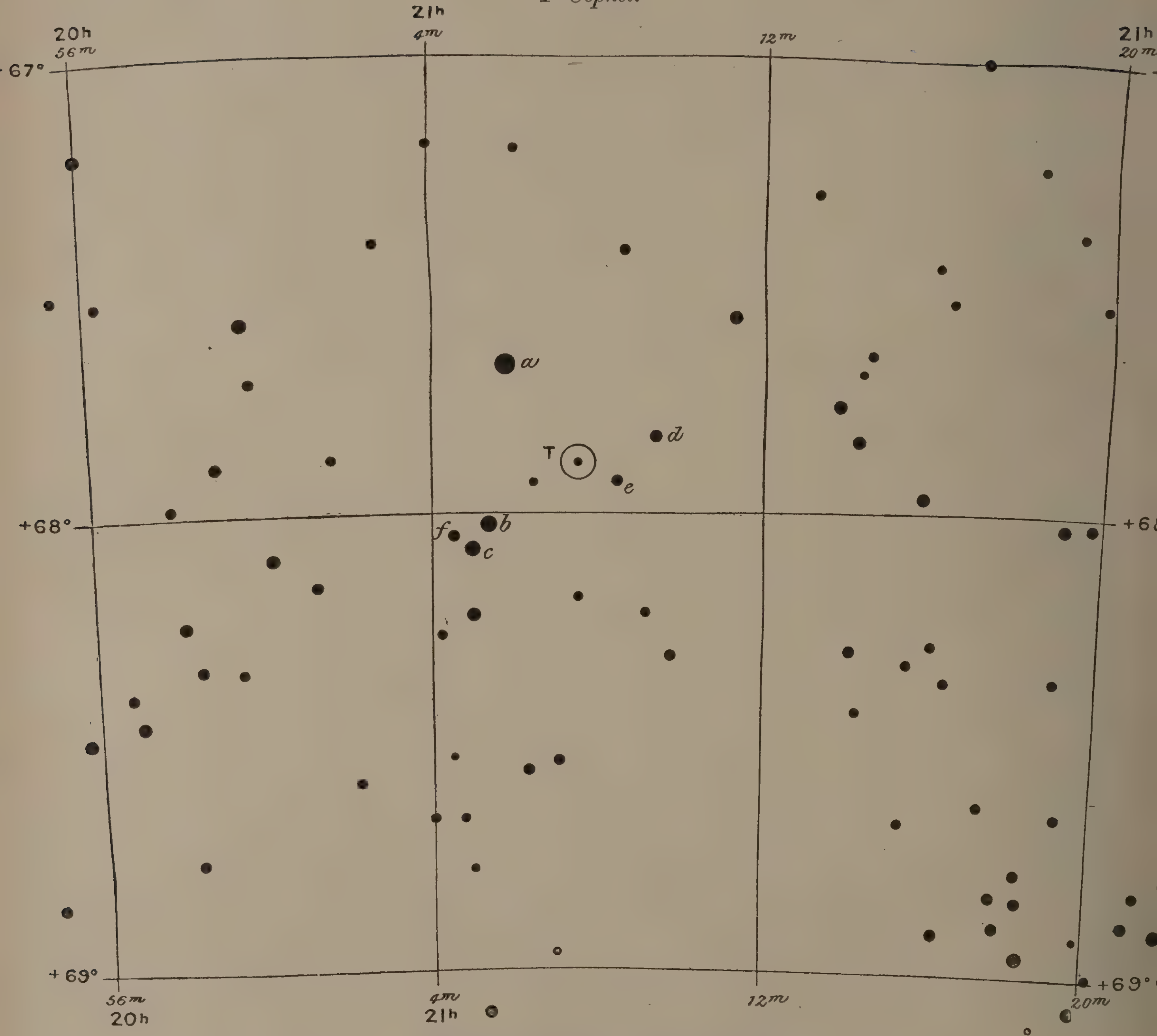
Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1890	h m					
Nov. 1	6 40	70	$c-1-2$ ...	8·2 8·1	8·15	Orange red. $b=a+4$ ∴ 7·5.
4	7 41	70	$c-2$... ...	8·1	8·1	Orange red. Gauged 8·1 8·2. $b=a+4$.
9	7 47	70	$c+2$; $d-6$...	8·5 8·5	8·5	Orange ruddy.
13	8 11	70	$c+4$; $d-4$	8·7 8·7	8·7	Red with orange tinge. $b=a+5$ ∴ 7·6.
28	7 1	70	$f+3$; $=g$ ...	10·0 10·0	10·0	No decided tint.
Dec. 1	7 12	70	$f+8$; $=h$; $k-3$	10·5 10·5 10·6	10·5	$b=a+5+6$.
9	6 13	115	$l+4$; $m-1$...	11·8 11·8	11·8	$b=a+6$ ∴ 7·7.
10	7 12	70 115	$l+4$; $m-1$...	11·8 11·8	11·8	$b=a+6$, $c-6$ ∴ 7·7.
12	8 4	115	$m+4$; $n-3$	12·3 12·3	12·3	Sky hazy; obsn. a little difficult. $b+a+7$, $c-5$ ∴ 7·8. Orange ruddy. *a* fine orange red.
13	7 0	115 191	$m+4$; $n-3$	12·3 12·3	12·3	$b=a+7$; $c-5$.
22	6 20	115 191	$m+6$; $n-1$	12·5 12·5	12·5	Hazy sky and moonlight. Obs. a little doubtful. $b=a+7$.
1891.						
Jan. 1	6 25	115	$n+2$ ...	12·8	12·8	
21	6 20	70 115	$f+8$; $g+5$; $=h$; $l-9$	10·5 10·5 10·5 10·5	10·5	Pretty well seen. $b=a+6$.
Feb. 1	6 8	70	$e+1$; $f-1$...	9·6 9·6	9·6	Ruddy. Twilight sky. $b=a+4$.
June 5	11 25	115	$m+3$; $n-4$	12·2 12·2	12·2	Doubtful observation. Low, and not quite clear.
July 28	10 35	70	$g+1$; $h-4$...	10·1 10·1	10·1	Slightly ruddy.
Aug. 10	10 10	70	$d+2$; $e-2$...	9·3 9·3	9·3	Distinctly ruddy.
12	10 24	70	$d+2$; $e-2$...	9·3 9·3	9·3	Ruddy. $b=a+2$.
Sept. 4	8 18	70 115	$l+2$; $m-3$...	11·6 11·6	11·6	$b=a+3$. Both ruddy.
Oct. 12	9 0	70	$l+4$; $m-1$...	11·8 11·8	11·8	$b=a+3+4$.
15	10 8	115	$l-1$... ...	11·3	11·3	$b=a+4$.
28	7 30	70	$=e$; $f-2$; $d+4$	9·5 9·5 9·5	9·5	Ruddy. Is *a* less than usual? Gaugings, $b=7·5$, $a=7·6$, $c=8·3$. *b* and *a* ruddy. Full tint.
Nov. 3	8 8	70	$d+1$; $e-3$...	9·2 9·2	9·2	Ruddy, a decided tint. $a=b$, $b-1$?
5	7 31	70	$c+5$; $d-2$...	8·8 8·8	8·8	Ruddy. $a=b+1+0$.
7	8 34	70	$d-3$; $c+5$...	8·8 8·8	8·8	Ruddy. $a=b-3$.
11	8 46	70	$c+3$; $d-5$...	8·6 8·6	8·6	Decidedly ruddy. $a=b-1$?
Dec. 14	7 20	70	$c-5$... ...	7·8	7·8	Very ruddy. $b=a+5$ ∴ 7·6. *a* appears about 7·1. A hazy, clouded sky. Failed to get obs. of *T Aquilæ* and *S Delphini*.
17	6 7	70	$c-4-5$; $b+2$	7·9 7·8 7·9	7·9	Very ruddy. 7·9 gauged. *a* 7·1, $b=a+6$ ∴ 7·7.
19	6 50	70	$c-3$; $b+2$...	8·0 8·0	8·0	Ruddy. $b=a+7$. *a* 7·1 ±. Bright.
1892.						
Jan. 4	6 55	70	$c+7$; $d-1$...	9·0 9·0	9·0	Very ruddy. *a* bright, 7·1 ± *b* 5 < *a* (∴ 7·6).

R Vulpeculæ—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1892. Jan. 7	h m 6 31	70	$c+5$; $d-3$...	8·8 8·8	8·8	Orange red. *a* gauged 7·1 7·2, *b* 7·5 7·6. *a* fine orange red. *b* ruddy. *R* gauged 8·8 8·9.
24	6 50	70	$h+3$; $k-1$...	10·8 10·8	10·8	$6\frac{1}{2}^h$ past meridn. and sky hazy.
May 30	11 40	70	$f-1$... ...	9·6	9·6	$a=b$ or rather less? 7·5? Pale orange tint. *b* gauged 7·5, *a* 7·6.
July 10	10 45	191	$m+5$; $n-2$...	12·4 12·4	12·4	Obs. difficult. Haze, and Moon rising. *a* ruddy yellow. $=b-1$.
28	10 39	70	$=k$; $l-5$ ...	10·9 10·9	10·9	$a=b$. Both 7·6 gauged.
Aug. 15	10 20	70	$=d$; $c+8$ ...	9·1 9·1	9·1	Ruddy.
Sept. 24	7 55	70	$c-1$ ...	8·2	8·2	Orange ruddy. *b* 7·5, *a* 7·6 gauged.
Oct. 11	8 29	70	$=d$	9·1	9·1	Ruddy. *b* 7·5 ruddy, *a* 7·6 very ruddy. Hazy sky.
15	8 15	70	$d+2$; $e-2$...	9·3 9·3	9·3	Orange ruddy.
17	8 5	70	$f-2$; $=e$ ...	9·5 9·5	9·5	Orange ruddy. *a* 7·4, *b* 7·5.
20	7 30	70	$e+1$; $f-1$...	9·6 9·6	9·6	Ruddy orange. *x* 7·4, *a*, *b* 7·5 gauged.
22	7 37	70	$=f$	9·7	9·7	Ruddy orange. *a* gauged 7·6, *b* 7·5.
Nov. 3	8 35	115	$l+1$; $m-4$...	11·5 11·5	11·5	Obs. rather difficult. Moon and haze. *a* very ruddy. About 7·5. *b* 7·6.
10	7 26	115	$=m$; $l+5$; $n-7$	11·9 11·9 11·9	11·9	Sky hazy, but fair estimate.
18	8 5	115	$n+7$ ...	13·3	13·3	13·5, or rather brighter estimated. About as much below *n* as *n* is below *m*.
26	8 35	115	$n+3$ ...	12·9	12·9	$a=b$, abt. 7·5.
30	7 40	115 191	$n+4$ ...	13·0	13·0	Abt. 13 est. Moonlight. *a* and *b* about equal, 7·5.
Dec. 1 2	6 38	115	$l+4$; $m-1$...	11·8 11·8	11·8	Past min. Brightening up. *a* barely so bright as *b*.
30	6 55	70	$d+2$; $f-4$...	9·3 9·3	9·3	Ruddy. Obs. difficult. Moon and haze.

Mr. Knott's diagram, epoch 1855.

T Cephei.



Magnitudes of Comparison Stars :

a	7·1	*d*	9·3
b	8·2	*e*	9·7
c	9·0	*f*	10·0

T Cephei.

THE following particulars are given in CHANDLER'S "Third Catalogue of Variable Stars" (*Astron. Journal*, No. 379).

No. 7609 *T Cephei*, R.A. for 1900·0 = $21^h\ 8^m\ 13^s$, Decl. = $+68°\ 5'{\cdot}0$.

Annual Variation $+0^s{\cdot}81$ and $+0'{\cdot}24$.

R.A. for 1855·0 = $21^h\ 7^m\ 33^s$, Decl. = $+67°\ 54'{\cdot}4$.

Redness = 6·3. Max. magnit. = 5·2 – 6·8. Min. = 8·6 – 10·7.

$M - m = 200^d$.

Maximum : 1873 July 19 = 2405359^d (Julian).

Period = 387^d.

(From fifteen observations of Max. and ten of Min., including observations in 1789, 1873–94.)

Discovered by CERASKI, 1878 ; confirmed by KNOTT.

T Cephei.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1881. Feb. 15	h m 7 45	70	$a+2$ ...	7·3	7·3	7·4 or 7·3 gauged. Fine orange red. Fine channelled spectrum. Qu. bright lines? eyepiece spectroscope and McClean. *a* gauged 7·2, *b* 8·2 8·3.
28	8 40	70	$a+8$; $b-3$...	7·9 7·9	7·9	8·0 8·1 est. *a* gauged 7·2, *b* 8·3.
Mar. 8	7 15	70	$b-1$; $a+9$...	8·1 8·0	8·05	Very red.
19	9 0	70	$b+2$... ...	8·4	8·4	8·3 8·5 est.
29	13 0	70	$b+3$; $c-5$...	8·5 8·5	8·5	Fine full red.
Apr. 26	10 20	70	$b+8$; $=c$ ...	9·0 9·0	9·0	Fine red, carmine.
May 20	11 26	70	$c+4$... ...	9·4	9·4	Fine red.
Aug. 2	10 45	70?	9·2 est. ...	...	9·2 est.	Decidedly ruddy.
Sept. 28	8 43	70	$b+2$... ...	8·4	8·4	8·4 gauged. Orange red. *a* 7·0 7·2, *b* 8·2, *c* 9·0 9·1. *d* gauged 9·3.
29	[8 30?]	70	$b+2+3$ ...	8·4 8·5	8·45	Comp. stars gauged. *a* 7·0, *b* 8·1, *c* 9·0, *d* 9·4 9·3, *e* 9·7, *f* 10·0. *T* fine fiery red.
Oct. 3	10 5	70	$b+0+1$ ...	8·2 8·3	8·25	Fine red.
5	9 0	70	$b+0+1$ ...	8·2 8·3	8·25	Comparison stars gauged. *a* 7·0 7·1, *b* 8·1 8·2, *c* 9·0 9·1. *T* fine ruddy. With full aperture, *not* less than *b*.
15	7 57	70	$b-0-1$ ...	8·2 8·1	8·15	Fine red. [*b* 8·1, *a* 7·1, *c* 9·0, *d* 9·4, gauged.]
19	7 20	70	$=b$	8·2 (8·1 gauged)	8·15	Fine orange red. Gauged 8·1, *b* 8·0, *c* 9·0, *d* 9·3 9·4, *e* 9·7 9 8.
Nov. 15	8 45	70	$b-1$... ...	8·1	8·1	Fine orange. 8·1 gauged.
17	8 40	70	$b-0-1$? ...	8·2 8·1?	8·1	8·1 gauged. Fine red.
Dec. 3	8 0	70	$a+4$; $b-6$...	7·5 7·6	7·55	7·6 gauged. Fine colour. Deep orange red.
8	8 30	70	$a+3$; $b-7$...	7·4 7·5	7·5	7·5 7·6 gauged. Fine orange red.
29	8 0 } 8 15 }	70	$a-2-1$? 6·8 7·0 gauged	6·9 7·0 6·8 7·0	6·9	*a* gauged 7·0 7·1, *b* 8·1 8·2. *T* fine yellow-orange tint, *not red*. A fine spectrum with dark bands. Are there one or two bright lines in the green and blue? Or is this contrast effect? Moonlight. Haze. (McClean's spectroscope.) The red end of the spectrum is not very bright. The light seems brightest in the middle part of the spectrum, with one or two black lines across it.
1882. Jan. 7	7 40	70	A good half-mag. > *a*	6·5	6·5	6·5 gauged. Fine golden orange with rosy flush. Qu. is it more nearly =6·0 than 6·5? It is very bright. A fine spectrum, banded, though there are one or two bright interspaces between the bands. *Bright* by *contrast*. There is, I think decidedly, no trace of *bright lines*. Three or four (?) dark bands. A dark line near boundary of red? The dark bands sharpest towards blue end of spectrum.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1882.	h m					
Jan. 21	6 40	70	$a-5-7$ ...	6·6 6·4	6·5	Fine orange red. At least $\frac{1}{2}$ mag. brighter than *a*.
Feb. 17	7 15	70	About equal to *a*?	7·1?	7·1?	Clouds coming over.
Mar. 3	8 7	70	$a+5$; $b-[6]$	7·6 7·6	7·6	7·6 gauged (*a* 7·1, *b* 8·1 gauged).
15	10 30	70	$a+7$; $b-5$...	7·8 7·7	7·75	Fine red with lilac tinge.
30	8 35	70	$b+0+1$ ...	8·2 8·3	8·25	8·3 gauged. Red with lilac tinge.
Apr. 20	11 0	70	$b+4$; $c-4$...	8·6 8·6	8·6	Red. Full colour.
May 15	11 0	70	$\frac{1}{2}(c+d)$	9·15	9·15	Ruddy, decided tint.
June 7	11 0	70	$\frac{1}{2}(d+e)$	9·5	9·5	Ruddy. Obs. interrupted by clouds.
15	11 5	70	$d+3$; $e-1$...	9·6 9·6	9·6	Distinctly ruddy.
July 24	10 15	115	$d+4$; $=e$ ...	9·7 9·7	9·7	Decidedly red.
Aug. 3	10 30	70	$d+6$; $=f$ ...	9·9 10·0	9·9	Ruddy. 9·8 10·0 gauged.
7	10 17	70	$=e$	9·7	9·7	Decided red tint.
9	10 5	70	$=e$	9·7	9·7	9·7 gauged. Red.
11	10 25	70	$d+3$; $e-1$...	9·6 9·6	9·6	Red.
19	8 50	70	$d+2$; $e-2$...	9·5 9·5	9·5	Fine red. Perhaps of the two *T* slightly nearer in mag. to *e*.
Oct. 2	8 30	70	$b+5$? $c-3$...	8·7 8·7	8·7	Fine red. Not so bright as *b*. Gauged about 8·7.
4	10 15	89	$b+5$... ...	8·7	8·7	Gauged 8·7. Fine red.
23	8 15	89	$=b$; $b+1$? $b-1$?	8·2	8·2	Orange ruddy. As nearly as possible $=b$ in telescope and in finder.
24	8 20	70	$=b$	8·2	8·2	*b* 8·2, *c* 9·0, *d* 9·5, *e* 9·8 (gauged).
Nov. 17	8 0	70	$b-2-1$; $a+9$	8·0 8·1 8·0	8·0	8·0 8·1 gauged. Orange red.
28	7 35	70	$a+8$; $b-2$...	8·0 8·0	8·0	Ruddy orange. Fine tint. 8·0 gauged.
Dec. 19	8 25	70	$a+1$; $b-10$	7·2 7·2	7·2	Gauged 7·2. Ruddy orange. Bright moonlight.
1883.						
Jan. 5	8 40	70	$a-0-1$ ...	7·1 7·0	7·05	Gauged 7·0 7·1. Orange ruddy.
26	7 10	70	$a-5$... ...	6·6	6·6	6·6 gauged. Orange red. *a* gauged 7·1.
Feb. 3	8 10	70	$a-7-10$? ...	6·4 6·1	6·2?	Fine orange red. 6·0 6·0+? gauged. *a* gauged 7·0.
5	8 30	70	$a-9$... ...	6·2	6·2	Gauged 6·2±. Orange red.
13	9 12	70	$a-7$... ...	6·3? 6·4	6·35	Ruddy orange.
15	8 50	70	$a-7$? ...	6·4	6·4	*a* 7·1 gauged. *T* gauged 6·4? 6·3?±. Fine ruddy orange.
22	7 45	70	$a-3$... ...	6·8	6·8	6·8 gauged. Fading? Apparently so. A moonlit sky.
24	6 45	70	$a-4$... ...	6·7	6·7	Ruddy orange. Gauged 6·7. *a* 7·1, *b* 8·2 gauged.
26	7 30	70	$a-4$... ...	6·7	6·7	6·6 6·7 gauged. Orange red. *a* 7·1.
28	8 35	70	$a-4$? ...	6·7	6·7?	Doubtful observation. Sky clouded.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1883 Mar. 2	h m 8 5	70	$a-4$... ...	6·7	6·7	Ruddy orange. *a* gauged 7·1. *T* gauged 6 7.
5	7 47	70	$a-3-4$ ...	6·8 6·7	6·75	Ruddy orange. Hazy sky.
12	8 34	70	$a+1$... ...	7·2	7·2	7·2 gauged. Ruddy orange.
14	8 45	70	$a+1$... ...	7·2	7·2	Ruddy orange. Hazy sky.
22	7 40	70	$a+1+2$; 7·3 gauged	7·2 7·3 7·3	7·3	7·3 gauged *a* 7·1. Ruddy, fine colour.
28	8 10	70	$a+5$; $b-6$...	7·6 7·6	7·6	Coppery red.
30	8 6	70	$a+5$; $b-6$...	7·6 7·6	7·6	Orange red. 7·6 gauged.
Apr. 7	8 2	70	$a+7$; $b-4$...	7·8 7·8	7·8	7·8 gauged. Ruddy.
May 7	10 5	70	$b+3$; $c-5$...	8·5 8·5	8·5	Red.
31	11 5	70	$b+9$; $c+1$; $d-2$	9·1 9·1 9·1	9·1	Red.
July 28	10 20	70	$=e$	9·7	9·7	Fine red.
Aug. 24	9 50	70	$e+3$? ...	10·0?	10·0	Decidedly red.
Oct. 2	8 35	70	$c+3$; $=d$; $e-4$	9·3 9·3 9·3	9·3	Red decidedly.
20	8 10	70	$d-4$; $c-1$...	8·9 8·9	8·9	Gauged 8·9. Fine red.
27	8 55	70	$b+6$; $c-2$...	8·8 8·8	8·8	Red. Hazy.
Nov. 10	8 43	70	$b+2$... ...	8·4	8·4	8·4 gauged. Fine red.
21	9 0	70	$b+0+1$ ...	8·2 8·3	8·25	8·3 gauged. Ruddy.
Dec. 6	8 17	70	$b-2$... ...	8·0	8·0	So, too, in finder. *T* orange red.
21	7 42	70	$b-2$... ...	8·0	8·0	Orange red.
1884. Jan. 12	7 48	70	$a+3$... ...	7·4	7·4	7·4 gauged. Fine red.
19	8 5	70	$a+2+3$ ...	7·3 7·4	7·35	7·4 gauged. Fine orange red.
Feb. 2	8 3	70	$a-0-1$ ...	7·1 7·0	7·05	Gauged 7·0.
11	8 40	70	$a-2-1$ ...	6·9 7·0	6·95	7·0 gauged. Ruddy orange.
29	8 5	70	$a-3$... ...	6·8	6·8	Fine orange red.
Mar. 5	10 10	70	$a-4-5$ ...	6·7 6·6	6·65	Fine orange red.
Apr. 8	10 40	70	$a+0+1$ ...	7·1 7·2	7·15	Ruddy. About equal *a*. Hazy sky. Difficult obs.
16	10 0	70	$a+4$; $b-7$...	7·5 7·5	7·5	Orange red.
21	8 55	70	$a+5$; $b-6$...	7·6 7·6	7·6	Fine red. Careful comparison in telescope and in finder.
June 30	11 27	70	$c+2$; $d-1$...	9·2 9·2	9·2	Ruddy.
July 7	10 45	70	$c+3$; $=d$; $e-4$	9·3 9·3 9·3	9·3	Orange red.
17	10 40	70	$d+3$; $e-1$...	9·6 9·6	9·6	9·6 gauged. Red.
Aug. 1	10 15	70	$d+4$; $=e$ ...	9·7 9·7	9·7	Full red.
22	8 30	70	$d+4$; $=e$ ...	9·7 9·7	9·7	9·7 gauged, so *c*. Fine red.
Oct. 4	7 5	70	$b+5+6$; $c-2-1$	8·7 8·8 8·8 8·9	8·8	Ruddy orange.
13	7 25	70	$b+4$; $c-4$...	8·6 8·6	8·6	8·6 gauged. Fine red.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1884.	h m					
Oct. 16	8 55	70	$b+4$; $c-4$ ...	8·6 8·6	8·6	Red.
22	7 5	70	$b+3$; $c-5$ ...	8·5 8·5	8·5	Red. *b* gauged 8·2. *T* 8·5. *c* 9·0. *d* 9·3.
28	9 20	70	$b+3$; $c-5$ ...	8·5 8·5	8·5	8·5 gauged. Orange red.
Nov. 7	11 0	70	$b+2$	8·4	8·4	Ruddy orange.
15	9 10	70	$=b$; $b-1$ ...	8·2 8·1	8·15	Fine orange ruddy.
22	8 42	70	$b-2-3$; $a+8+9$	8·0 7·9 7·9 8·0	7·95	7·9 gauged. Orange red.
28	8 46	70	$a+7$; $b-4$ ..	7·8 7·8	7·8	Orange red.
Dec. 4	8 30	70	$a+5$; $b-6$...	7·6 7·6	7·6	Orange red.
17	8 45	70	$a+6$; $b-5$...	7·7 7·7	7·7	Orange ruddy.
1885.						
Jan. 6	8 45	70	$a+3+4$; $b-7-8$	7·4 7·5 7·5 7·4	7·45	Abt. 7·5 gauged. Orange red.
20	8 42	70	$a+2$; $b-9$...	7·3 7·3	7·3	Orange tint.
Feb. 5	6 54	70	$=a$	7·1	7·1	Orange tint. Gauged $=a$.
9	8 30	70	$=a$	7·1	7·1	So, also, in finder, and with 8in·1 aperture. Yellow, with ruddy tinge.
18	7 30	70	$=a$	7·1	7·1	*T* and *a* gauged 7·1. Ruddy orange.
Mar. 7	8 10	70	$a-5-4$ ...	6·6 6·7	6·65	6·6 6·7 gauged. *a* 7·1. *T* fine orange red.
10	8 0	70	$a-4$... ...	6·7	6·7	Orange tint. Clouds very troublesome.
14	8 32	70	$a-5$... ...	6·6	6·6	Golden, with rosy flush. 6·6 6·7.
23	10 30	70	$a-4-5-5$..	6·7 6·6 6·6	6·6	Orange ruddy. By relative gauging (7·4 = 7·0) 6·7 gauged.
30	10 30	70	$a-9-10$ ...	6·1 6·2	6·15	Fine ruddy orange. Almost as much brighter than *a* as *a* is than *b*. Bright moonlight.
Apr. 3	10 30	70	$a-8-9$ ...	6·3 6·2	6·25	Ruddy orange.
6	10 30	70	$a-6$... ...	6·5	6·5	Orange ruddy. Abt. 6·5 gauged. Not *less* than 6·5.
17	10 30	70	$a-2-1$ ...	6·9 7·0	6·95	*a* and *T* gauged nearly equal.
29	10 0	70	$a-1$ ...	7·0	7·0	Ruddy orange. Moonlight and hazy.
May 11	10 55	70	$a+2+3$ ...	7·3 7·4	7·35	Orange ruddy, fine tint.
15	10 0	70	$a+2+3$ ...	7·3 7·4	7·35	Fine orange red. Gauged 7·4. *T* and *a* more nearly equal in telescope than in finder. In tel. reduced to $2\frac{1}{4}$ inch $T=a+2+3$.
29	9 55	70	$a+6+7$; $b-5-4$	7·7 7·8 7·7 7·8	7·75	Orange red. 7·8 gauged.
June 17	10 35	70	$a+11$; $b+0+1$	8·2 8·2 8·3	8·2	Orange ruddy. Well on the wane. 5h from meridian.
July 10	11 40	70	$b+4$; $c-4$...	8·6 8·6	8·6	Ruddy, full tint.
23	10 13	70	$b+6$; $c-2$; $d-5$	8·8 8·8 8·8	8·8	Orange red. 8·8 gauged.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1885.	h m					
Aug. 10	11 45	70	$d+1$; $e-3$...	9·4 9·4	9·4	Ruddy.
27	9 15	70	$=d$	9·3	9·3	Rather doubtful observation.
29	8 55	70	$d+2$; $e-2$...	9·5 9·5	9·5	9·5 9·6 gauged. Ruddy.
Oct. 1	7 20	70	$d+1+2$; $e-3-2$	9·4 9·5 9·4 9·5	9·45	Ruddy.
7	7 45	70	$=d$; $\frac{1}{2}(c+e)$	9·3 9·35	9·3	9·3 gauged. *Not less than a.* Ruddy decidedly.
27	6 45	70	$b+6$; $d-5$...	8·8 8·8	8·8	Orange ruddy. Gauged 8·9. *b* gauged 8·2, *c* 9·0 9·1, *d* 9·3.
Nov. 4	7 50	70	$b+5$; $c-3$...	8·7 8·7	8·7	Gauged 8·7. *c* gauged 9·0. *T* ruddy.
7	8 10	70	$b+4$... ...	8·6	8·6	Coppery red. Gauged 8·6. *b* gauged 8·2.
16	7 45	70	$b+2$... ...	8·4	8·4	Full ruddy.
Dec. 1	9 50	70	$=b$	8·2	8·2	Fine orange red.
10	6 30	70	$=b$	8·2	8·2	Orange red. 8·2 gauged. So *b*.
15	7 48	70	$b+1$... ...	8·3	8·3	Gauged 8·3. *b* 8·2. *T* orange red.
1886. Mar. 11	7 25	70	$a-7$... ...	6·4	6·4	6·5 gauged. *a* 7·0 7·1. Orange red.
May 15	8 30	70	$=a$; $a-1$?...	7·1 7·0	7·05	*T* ruddy orange. Daylight.
June 1	10 53	70	$a+7$; $b-4$...	7·8 7·8	7·8	Ruddy orange. 7·7 gauged.
23	10 23	70	$a+8$; $b-3$...	7·9 7·9	7·9	Orange red. 7·9 gauged.
30	11 20	70	$a+10$; $b-1$	8·1 8·1	8·1	Full orange red. 8·1 8·2 gauged.
July 5	11 20	70	$=b$	8·2	8·2	So too in finder. Both stars gauged 8·2. *T* full orange red.
15	11 15	70	$b+1+2$; $c-8-9$	8·3 8·4 8·2 8·1	8·25	Orange ruddy.
24	10 50	70	$b+3$; $d-8$..	8·5 8·5	8·5	Full ruddy.
Aug. 10	9 45	70	$b+6$; $d-5$..	8·8 8·8	8·8	8·8 9·0. Ruddy. Full colour.
Sept. 30	7 0	70	$d+2$; $e-2$...	9·5 9·5	9·5	Red. So too in finder.
Oct. 21	8 0	70	$d+3$; $e-1$...	9·6 9·6	9·6	Ruddy. Not very clear sky.
29	8 15	70 115	$d+1+2$; $e-3-2$	9·4 9·5 9·4 9·5	9·45	Ruddy. Decided tint.
Nov. 6	8 10	70	$d+1+2$; $e-3-2$	9·4 9·5 9·4 9·5	9·45	Orange ruddy. In finder certainly not so bright as *d*.
16	7 20	70	$d+0+1$; $e-3$	9·3 9·4 9·4	9·4	Orange red.
22	8 50	70	$d-0-1$; $e-4-5$	9·3 9·2 9·3 9·2	9·25	Full ruddy.
29	7 15	70	$d-2$; $c+1$...	9·1 9·1	9·1	Ruddy.
Dec. 1	6 45	70	$=c$; $d-3$ ...	9·0 9·0	9·0	9·0 gauged. Red orange tint.
4	8 0	70	$=c$; $d-3$ ...	9·0 9·0	9·0	Ruddy.
14	8 10	70	$b+6+7$; $c-2-1$	8·8 8·9 8·8 8·9	8·85	Orange red.
18	7 10	70	$b+5$; $c-3$...	8·7 8·7	8·7	*T* gauged 8·7, *c* 9·0. *T* orange ruddy.
25	7 45	70	$c-1$; $b+7$...	8·9 8·9	8·9	Ruddy orange.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1887.	h m					
Jan. 12	9 45	70	$a+7$; $b-4$...	7·8 7·8	7·8	Orange red.
25	7 35	70	$a+8$; $b-3$...	7·9 7·9	7·9	Orange red. 8·0 gauged.
Feb. 7	10 15	70	$a+5$; $b-6$...	7·6 7·6	7·6	7·6 gauged. Orange red.
12	8 10	70	$a+5$; $b-6$...	7·6 7·6	7·6	7·6 gauged. Orange red.
15	7 40	70	$a+5$; $b-6$...	7·6 7·6	7·6	Gauged 7·6. b gauged 8·2.
26	8 47	70	$=a$	7·1	7·1	Gauged 7·1. Ruddy orange.
Mar. 12	7 0	70	$a-5$... ...	6·6	6·6	Gauged 6·6. Orange red, fine colour.
18	7 40	70	$a-7$... ...	6·4	6·4	Ruddy orange. 6·5 ± gauged.
26	8 30	70	$a-8$... ...	6·3	6·3	Nearly as much brighter than a as a is than b. 11ʰ 20ᵐ past meridian.
Apr. 11	10 10	70	$a-3-4$ ...	6·8 6·7	6·75	6·7 gauged. Orange red. Certainly fainter than when last obsd?
16	9 45	70	$a-5$? ...	6·6?	6·6?	6·6 gauged. a gauged 7·1. Red orange tint. Under-estimated on the 11th?
30	10 35	70	$a-4$... ...	6·7	6·7	6·7 6·8 gauged. Orange red.
May 10	11 12	70	$a-2$... ...	6·9	6·9	Certainly brighter than a both in telescope and in finder. Ruddy. Full colour.
20	10 35	70	$=a$? ...	7·1?	7·1?	A little doubtful. Orange red.
June 13	11 5	70	$a+6$; $b-5$...	7·7 7·7	7·7	Orange red.
18	9 55	70	$\frac{1}{2}(a+b)$ ...	7·65	7·65	7·6 gauged. Full twilight.
30	11 0	70	$a+5$; $b-6$...	7·6 7·6	7·6	Orange red. 7·6 gauged. a gauged 7·1.
July 18	10 20	70	$a+7$; $b-4$...	7·8 7·8	7·8	7·9 gauged. Orange red.
Aug. 12	10 5	70	$=b$	8·2	8·2	8·2. Orange ruddy.
Oct. 1	8 0	70	$b+8$; $=c$ ...	9·0 9·0	9·0	So, too, in finder, or $c-1$? T orange tint. Not full red.
17	8 20	70	$c+2$; $d-1$...	9·2 9·2	9·2	9·3 gauged. Ruddy. d gauged 9·3 9·4, e 9·7 9·8.
31	7 25	70	$c+2$; $d-1$...	9·2 9·2	9·2	Ruddy orange.
Nov. 14	8 20	70	$d-2-3$; $c+0+1$	9·1 9·0 9·0 9·1	9·05	Gauged 9·0 9·1. Orange tint.
30	7 36	70	$c+1$; $d-3$...	9·1 9·1	9·1	T full ruddy. Gauged 9·1 9·2. d gauged 9·4.
Dec. 5	7 30	70	$c+3$; $d-2$...	9·3 9·3	9·3	d 9·5. Qu. is this star (d) variable? T orange ruddy.
15	7 15	70	$=c$	9·0	9·0	9·0 gauged. Orange red. d gauged 9·5.
1888.						
Jan. 9	8 10	70	$b-2$... ...	8·0	8·0	Orange red.
18	7 35	70	$a+6$; $b-5$...	7·7 7·7	7·7	7·6 7·7 gauged. Orange red.
23	8 12	70	$a+5$; $b-7$...	7·6 7·6	7·6	Orange red.
Feb. 7	7 20	70	$a-0-1$ ...	7·1 7·0	7·05	Orange red. A rather hurried observation; clouds came over.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mag.	Mean Mag.	Remarks.
1888.	h m					
Mar. 1	7 0	70	$a-3$... ...	6·8	6·8	Orange red.
5	7 20	70	$=a$	7·1	7·1	Orange red. In finder as in telescope about equal to a. So, too, with reduced aperture in finder.
21	8 0	70	$a-0-1$ ...	7·1 7·0	7·05	Gauged equal to or slightly greater than a; orange ruddy.
Apr. 14	10 50	70	$a-4$... ...	6·7	6·7	Ruddy orange. 6·7 gauged; a 7·1 gauged.
26	10 35	70	$a-9$... ...	6·2	6·2	Orange red. 6·2 ± gauged.
May 1	8 55	70	$a-9$... ...	6·2	6·2	About $6\frac{1}{4}$ gauged. Orange red.
10	10 10	70	$a-9-8$ ...	6·2 6·3	6·25	Gauged about $6\frac{1}{4}$, a 7·1. Orange red.
23	10 10	70	$a-7-8$ ...	6·4 6·3	6·35	Fine orange red, $6\frac{1}{4}$ $6\frac{1}{2}$ est.
June 30	10 50	70	$a-3$... ...	6·8	6·8	Orange red.
Aug. 8	10 40	70	$=b$	8·2	8·2	Orange red. About a magnitude less than a. Obsd. in large telescope and in finder.
Oct. 5	9 0	70	$d+1$; $e-3$...	9·4 9·4	9·4	Orange red. So in telescope and in finder.
10	9 0	70 115	$d+1+2$; $e-3$	9·4 9·5 9·4	9·4	Ruddy; hazy sky; doubtful observation.
11	9 0	70	$d+1$; $e-3$...	9·4 9·4	9·4	Orange red.
15	9 45	70	$d+1$; $e-3$...	9·4 9·4	9·4	Very red.
23	8 15	70	$d+1$; $e-3$...	9·4 9·4	9·4	Red.
Nov. 3	8 25	70 38	$d+3+4$; $e-1-0$	9·6 9·7 9·6 9·7	9·65	Red.
6	7 10	70	$=e$; $d+4$ ...	9·7 9·7	9·7	Ruddy. T and e gauged 9·7.
13	7 20	70	$=e$; $d+4$ ...	9·7 9·7	9·7	Red.
20	7 55	70	$=e$; $d+4$ ...	9·7 9·7	9·7	Orange ruddy.
26	8 0	70	$e+1$; $d+5$...	9·8 9·8	9·8	Red. Clouds coming over. Bad definition. Observed in telescope and in finder.
Dec. 5	8 45	70	$d+3$; $e-1$...	9·6 9·6	9·6	Ruddy.
10	7 33	70	$=d$; $e-4$ ...	9·3 9·3	9·3	Orange red.
26	7 35	70	$c+2$; $d-1$...	9·2 9·2	9·2	Orange red. 9·2 gauged.
1889.						
Jan. 1	10 0	70	$c+2$... ...	9·2	9·2	Ruddy. d less than 9·3? More like 9·5.
27	...	70	$b+4$; $c-4$...	8·6 8·6	8·6	8·6 gauged. Orange red. Full coloured.
Feb. 2	8 10	70	$b+3+4$; $c-5-6$	8·5 8·6 8·5 8·4	8·5	Full orange red. Gauged 8·5 8·6.
7	9 0	70	$b+2$; $c-6$...	8·4 8·4	8·4	Orange red, full coloured.
21	8 33	70	$a+8$; $b-3$...	7·9 7·9	7·9	About 7·8 7·9 gauged. Full orange red.
Mar. 6	8 48	70	$a+8$; $b-3$...	7·9 7·9	7·9	Orange red.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1889.	h m					
Apr. 11	8 45	70	$a+7$; $b-4$...	7·8 7·8	7·8	Orange red.
June 3	10 30	70	$a-10$ ...	6·1	6·1	At least so much brighter than *a* as *a* is than *b*.
Aug. 7	9 45	70	$a+5$... ...	7·6	7·6	7·6 gauged. Orange ruddy. *Certainly decidedly* less than *a*.
Sept. 6	8 50	70	$b+1$... ...	8·3	8·3	Orange red. In telescope and in finder slightly less than *b*.
10	8 25	70	$a+2$... ...	8·4	8·4	8·4 gauged. Orange red.
Oct. 21	8 30	70	$d+0+1$; $e-3-4$	9·3 9·4 9·4 9·3	9·35	Orange red.
23	7 51	70	$d+1$; $e-3$...	9·4 9·4	9·4	Orange ruddy.
25	8 55	70	$d+1$; $e-3$...	9·4 9·4	9·4	Obsd. in telescope and in finder. Orange ruddy.
31	8 50	70	$d+1+2$; $e-2-3$	9·4 9·5 9·5 9·4	9·45	In large telescope *T* looks more nearly equal *d* than it does in finder. Full orange red.
Nov. 2	8 54	70	$d+2$; $e-2$...	9·5 9·5	9·5	Full colour, orange red. So too in finder. (This last refers to light estimates.)
12	8 30	70	$d+3$; $e-1$...	9·6 9·6	9·6	Ruddy. 9·6 gauged.
25	8 15	70	$d+4$; $=e$ ...	9·7 9·7	9·7	Orange tint.
30	9 55	70	$d+3$; $e-1$...	9·6 9·6	9·6	Orange ruddy.
Dec. 4	8 25	70	$d+3$; $e-1$...	9·6 9·6	9·6	Ruddy orange.
11	8 15	70	$d+2$; $e-2$...	9·5 9·5	9·5	Orange ruddy.
24	8 10	70	$=d$; $e-4$ ...	9·3 9·3	9·3	Ruddy orange.
1890.						
Jan. 4	9 10	70	$d-1$; $c+2$...	9·2 9·2	9·2	Ruddy orange. Between clouds.
Mar. 12	7 45	70	$b+2$... ...	8·4	8·4	8·4 gauged. Ruddy orange.
31	8 45	70	$a+7$; $b-4$...	7·8 7·8	7·8	Orange red.
Apr. 4	8 32	70	$a+7$; $b-4$...	7·8 7·8	7·8	7·8 gauged. Orange red.
22	10 25	70	$a+5$; $b-6$...	7·6 7·6	7·6	Full red with orange tinge. 7·6 gauged.
29	10 10	70	$a+6$; $b-5$...	7·7 7·7	7·7	Orange ruddy.
May 13	10 23	70	$a+4$; $b-7$...	7·5 7·5	7·5	Orange ruddy.
June 9	10 50	70	$a-6$... ...	6·5	6·5	Orange red.
Aug. 1	10 25	70	$=a$	7·1	7·1	Red with orange tinge.
8	10 25	70	$a+3$; $b-8$...	7·4 7·4	7·4	About 7·5 gauged.
18	9 48	70	$a+7$; $b-4$...	7·8 7·8	7·8	Orange ruddy. Pretty full colour. Fainter in finder (2-inch) than in telescope.
23	10 0	70	$a+6$; $b-5$...	7·7 7·7	7·7	7·6 gauged. Full red with orange tinge.
30	8 35	70	$a+7$; $b-4$...	7·8 7·8	7·8	Red with orange dash.
Sept. 4	8 53	70	$b-3$; $a+8$...	7·9 7·9	7·9	Red with orange flush.
13	8 10	70	$a+9$; $b-2$...	8·0 8·0	8·0	Red with orange tinge.
15	8 20	70	$a+8$; $b-3$...	7·9 7·9	7·9	Gauged 7·9. Deep orange red.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1890.	h m					
Oct. 25	7 25	70	$b+7$; $c-1$ ...	8·9 8·9	8·9	Gauged 8·9 Red with orange tinge.
Nov. 1	8 20	70	$c+1$; $d-3$...	9·1 9·1	9·1	d gauged 9·4. T red. I think no orange in it.
4	8 10	70	$c+3$; $d-2$...	9·3 9·1	9·2	T gauged 9·3 9·4, d 9·5.
9	8 10	70	$c+4$; $d-1$...	9·4 9·2	9·3	d gauged 9·5. T 9·4. Orange red.
13	8 45	70	$c+4$; $d-1$...	9·4 9·2	9·3	Orange red. d 9·5 $=e-2$.
28	7 30	70	$c+3$; $d-1$...	9·3 9·2	9·25	Orange red. d 9·4.
Dec. 9	7 3	70	$d-1$; $c+3$...	9·2 9·3	9·25	Orange red. d 9·4.
22	9 0	70	$=d$; $c+4$; $e-3$	9·3 9·4 9·4	9·4	d 9·4. Orange red.
1891.						
Jan. 1	7 20	70	$c+3$; $d-1$...	9·3 9·2	9·25	d 9·4. T orange red.
16	8 30	70	$c+3$; $e-4$...	9·3 9·3	9·3	Orange red.
Feb. 8	7 10	70	$c+1$? ...	9·1?	9·1?	Orange red. A brief view. Clouds came over. Obs. doubtful.
	7 20	70	$c+0+1$ ...	9·0 9·1	9·05	Clear again. T orange red. Equal or nearly so to c.
18	8 50	70	$b+6$; $c-2$...	8·8 8·8	8·8	Orange red.
24	7 45	70	$b+3$... ...	8·5	8·5	Orange red, fine colour. 8·5 8·6 gauged.
27	7 31	70	$b+3$; $c+5$ ...	8·5 8·5	8·5	Orange red. Full coloured.
Mar. 26	7 59	70	$b+1$... ...	8·3	8·3	Deep orange red.
Apr. 6	10 25	70	$a+7$; $b-4$...	7·8 7·8	7·8	Red with orange tinge. Fine colour.
May 7	10 0	70	$a+6$; $b-5$...	7·7 7·7	7·7	Orange red.
June 5	10 20	70	$=a$	7·1	7·1	Orange red.
July 28	10 43	70	$a-3$... ...	6·8	6·8	Orange red.
Aug. 10	10 20	70	$a-7$... ...	6·4	6·4	Full orange red.
Sept. 4	8 35	70	$a+1$... ...	7·2	7·2	Fine red with orange tinge. Gauged slightly less than a.
Oct. 12	8 48	70	$b+5$; $c-3$...	8·7 8·7	8·7	Red with orange tinge.
23	8 3	70	$b+6$; $c-2$ ...	8·8 8·8	8·8	Full red with orange tinge.
28	9 30	70	$=c$	9·0	9·0	9·0 gauged. Red with orange tinge.
Nov. 3	8 52	70	$c+2$; $d-2$...	9·2 9·2	9·2	Orange red. d 9·4.
11	9 4	70	$c+3$; $d-1$...	9·3 9·2	9·25	Orange red. 9·3 gauged.
Dec. 17	7 56	70	$d+3$; $e-1$...	9·6 9·6	9·6	Orange red.
1892						
Jan. 4	8 10	70	$d+4$; $=e$ ...	9·7 9·7	9·7	Orange ruddy.
7	6 45	70	$d+3+4$; $e+0+1$	9·6 9·7 9·7 9·8	9·7	d 9·4, e 9·7. T orange red.
15	7 23	70 115	$=e$; $d+4$ ...	9·7 9·7	9·7	Orange red. Hazy sky.
20	7 58	70	$=e$; $d+4$ ...	9·7 9·7	9·7	Obsn. rather doubtful. Cloudy sky.
24	7 21	70	$e-0-1$; $d+3+4$	9·7 9·6 9·6 9·7	9·65	Very ruddy.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1892.	h m					
Feb. 1	9 7	70	$d+3$; $e-1$...	9·6 9·6	9·6	Orange red.
13	8 43	70	$c+3$; $=d$; $e-4$	9·3 9·3 9·3	9·3	Orange red, full tint.
22	7 15	70	$c+2$; $d-1$...	9·2 9·2	9·2	Orange red.
27	7 44	70	$c+2$; $d-1$...	9·2 9·2	9·2	Red orange.
Mar. 12	8 5	70	$c-2$; $d-5$; $b+6$	8·8 8·8 8·8	8·8	Orange red. Moon and sky hazy.
19	7 35	70	$b+5$; $c-3$...	8·7 8·7	8·7	Orange red, full coloured. 8·7 gauged.
Apr. 1	10 6	70	$b+4$... ...	8·6	8·6	Orange red.
9	8 45	70	$=b$	8·2	8·2	Orange red.
19	10 36	70	$b-1$... ...	8·1	8·1	Orange red.
May 6	9 7	70	$a+9$; $b-2$...	8·0 8·0	8·0	Orange red.
21	10 5	70	$a+9$; $b-2$...	8·0 8·0	8·0	Orange red.
30	10 29	70	$a+7$; $b-4$...	7·8 7·8	7·8	Orange red; fine tint.
July 10	10 57	70	$a-2$... ...	6·9	6·9	6·9 gauged. Orange with red tinge.
28	10 52	70	$a-6$... ...	6·5	6·5	Red with orange cast. 6·5 gauged.
Aug. 15	10 54	70	As much $>a$ as a is $>b=a-11$	6·0	6·0	Fine ruddy orange.
Sept. 24	8 25	70	$a+2+3$ ...	7·3 7·4	7·35	7·4 gauged. Red with orange cast.
Oct. 11	8 50	70	$=b$	8·2	8·2	Orange red.
20	7 46	70	$b+1$... ...	8·3	8·3	8·3 gauged. Orange red.
Nov. 3	8 46	70	$b+7$; $c-1$...	8·9 8·9	8·9	Orange red.
18	8 38	70	$c+3$; $=d$ ...	9·3 9·3	9·3	Orange red.
26	9 5	70	$c+3$; $=d$ ...	9·3 9·3	9·3	Orange red; full of colour.
Dec. 12	7 30	70	$c+4$; $d+1$...	9·4 9·4	9·4	Orange red. Gauged 9·4, as also *d*.
30	7 6	70	$d+4$; $=e$ ...	9·7 9·7	9·7	Orange red.
1893.						
Jan. 15	7 20	70	$d+3$; $e-1$...	9·6 9·6	9·6	Orange red.
20	10 5	70 115	$=e$; $d+4$ ...	9·7 9·7	9·7	Ruddy tint.
Feb. 4	8 7	70	$d+4$; $=e$...	9·7 9·7	9·7	Orange ruddy.
7	7 30	70 115	$=e$; $d+4$ ...	9·7 9·7	9·7	Orange ruddy.
Mar. 25	*8 47	70	$c+3$; $=d$ ...	9·3 9·3	9·3	Orange red.
31	9 0	70	$=c$	9·0	9·0	9·0 gauged. Full red with slight orange tint.
Apr. 4	8 56	70	$=c$	9·0	9·0	Orange red.
21	9 45	70	$b+4$; $c-4$...	8·6 8·6	8·6	Orange red.
May 6	9 53	70	$b+1$... ...	8·3	8·3	Orange red.
June 30	10 0	70	$a+6$; $b-5$...	7·7 7·7	7·7	7·7 7·8 gauged. Clear orange red.
Aug. 4	10 45	70	$a-11$ ...	6·0	6·0	6·0 gauged. Orange red.

T Cephei—continued.

Date of Observation.	G.M.T.	Power.	Estimated equal to.	Deduced Mags.	Mean Mag.	Remarks.
1893. Aug. 8	h m 10 22	70	$a-11$ ...	6·0	6·0	6·0 gauged. Orange red. Splendid spectrum. Black absorption bands. Bright spaces (two or three) almost as bright as bright lines. Eyepiece spectroscope and McClean's.
14	10 50	70	$a-11$ ...	6·0	6·0	Orange red. Fine tint.
Sept. 30	8 35	70	$=a$	7·1	7·1	Orange red.
Oct. 12	8 9	70	$a+3$... ...	7·4	7·4	7·4 gauged. Orange red; full coloured.
27	7 27	70	$a+8$; $b-3$...	7·9 7·9	7·9	Orange red.
Nov. 6	8 58	70	$b+4$; $c-4$...	8·6 8·6	8·6	Orange red.
13	8 25	70	$b+4$; $c-4$...	8·6 8·6	8·6	Very red; hardly any orange in it.
Dec. 2	8 40	70	$=c$	9·0	9·0	Orange red.
30	7 53	70	$c+2$; $d(9·4)-2$	9·2 9·2	9·2	Orange red.
1894. Jan. 31	6 55	70	$d(9·4)+1$; $e-2$	9·5	9·5	9·5.

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TO WHOM

THE MEDALS OR TESTIMONIALS OF THE SOCIETY

HAVE BEEN ADJUDGED.

1823.

June 13. CHARLES BABBAGE, Esq.

The Gold Medal.—For his Invention of an Engine for computing and printing Mathematical Tables.

Professor JOHANN FRIEDRICH ENCKE.

The Gold Medal.—For his Investigations relative to the Comet which bears his name.

CHARLES RUMKER, Esq.

The Silver Medal.—For his Rediscovery of ENCKE'S Comet in 1822.

M. JEAN LOUIS PONS.

The Silver Medal.—For his Discovery of Two Comets in 1822.

1826.

Feb. 7. J. F. W. HERSCHEL, Esq., and JAMES SOUTH, Esq.

The Gold Medal, each.—For their important Researches on the subject of Multiple Stars.

Feb. 10. Professor STRUVE.

The Gold Medal.—For his important Researches on the subject of Multiple Stars.

1827.

Feb. 2. FRANCIS BAILY, Esq.

The Gold Medal.—For his "New Tables for determining the places of 2,881 Stars."

WILLIAM SAMUEL STRATFORD, Esq.

The Silver Medal.—For his Superintendence of the Computation of "New Tables for determining the places of 2,881 Stars."

1827.
Feb. 5. Colonel Mark Beaufoy.
The Silver Medal.—For his valuable Collection of Observations, particularly those of the Eclipses of *Jupiter's* Satellites.

1828.
Jan. 11. Sir Thomas Macdougall Brisbane, K.C.B.
The Gold Medal.—For his Establishment of an Observatory, and for an important series of Observations made at Paramatta.

James Dunlop, Esq.
The Gold Medal.—For his Observations of the Nebulæ of the Southern Hemisphere.

Feb. 4. Miss Caroline Herschel.
The Gold Medal.—For her recent reduction, to January 1800, of the Nebulæ discovered by Sir William Herschel.

1829.
Jan. 9. Rev. William Pearson.
The Gold Medal.—For his work entitled "An Introduction to Practical Astronomy."

Professor Bessel.
The Gold Medal.—For his Zone Observations.

Professor Schumacher.
The Gold Medal.—For the publication of his various Astronomical Tables, and the "Astronomische Nachrichten."

1830.
Jan. 8. Mr. William Richardson.
The Gold Medal.—For his Investigation of the Constant of Aberration.

Professor Encke.
The Gold Medal.—For the New Berlin Ephemeris.

1831.
Jan. 14. Captain Kater.
The Gold Medal.—For his Invention of the Vertical Floating Collimator.

Baron Damoiseau.
The Gold Medal.—For his Memoir upon the Theory of the Moon, and for his Lunar Tables.

1833.
Jan. 11. Professor Airy.
The Gold Medal.—For his Discovery of the long Inequality of *Venus* and the Earth.

1835.
Jan. 9. Lieutenant JOHNSON.
The Gold Medal.—For his Catalogue of 606 Southern Stars.

1836.
Jan. 8. Sir JOHN F. W. HERSCHEL.
The Gold Medal.—For his Catalogue of Nebulæ, printed in the "Philosophical Transactions" for 1833.

1837.
Jan. 13. Professor ROSENBERGER.
The Gold Medal.—For his Investigations relative of HALLEY'S Comet.

1839.
Jan. 11. Hon. JOHN WROTTESLEY.
The Gold Medal.—For his Catalogue of the Right Ascensions of 1,318 Stars.

1840.
Jan. 10. M. JEAN PLANA.
The Gold Medal.—For his Work, entitled "Théorie du Mouvement de la Lune."

1841.
Jan. 8. Professor BESSEL.
The Gold Medal.—For his Observations and Researches on the Parallax of 61 *Cygni.*

1842.
Jan. 14. M. HANSEN.
The Gold Medal.—For his Researches in Physical Astronomy.

1843.
Jan. 13. FRANCIS BAILY, Esq.
The Gold Medal.—For his Experiments to determine the Mean Density of the Earth in repetition of what is generally termed the "Cavendish Experiment."

1845.
Jan. 10. Captain WILLIAM HENRY SMYTH, R.N.
The Gold Medal.—For his "Bedford Catalogue," forming the second part of his work entitled "Celestial Cycle."

1846.
Jan. 9. GEORGE BIDDELL AIRY, Esq., Astronomer Royal.
The Gold Medal.—For his Reduction of the Observations of Planets made at the Royal Observatory, Greenwich, from 1750 to 1830.

1848. *Testimonials were awarded to*

Jan. 14. George Biddell Airy, Esq., Astronomer Royal.
For the Lunar Reductions recently made at Greenwich.

John Couch Adams, Esq.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Professor Argelander.
For his Catalogue of Stars.

George Bishop, Esq.
For the Foundation of an Observatory leading to various Astronomical Discoveries.

Lieut.-Col. George Everest.
For his Measurement of the Indian Arc.

Sir John F. W. Herschel.
For his Work on the Southern Hemisphere.

Professor P. A. Hansen.
For his Lunar Theory and Computation of Perturbations.

M. Hencke.
For his Discovery of two Planets, *Astrœa* and *Hebe*.

John Russell Hind, Esq.
For his Discovery of two Planets, *Iris* and *Flora*.

M. Le Verrier.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Sir John Lubbock.
For his Researches in the Theory of Perturbations.

M. M. Weisse.
For his Catalogue of Stars in Bessel's Zones.

1849.
Feb. 9. William Lassell, Esq.
The Gold Medal.—For the construction of his Equatorial Instrument and for the Discoveries made with it.

1850.
Feb. 8 M. Otto von Struve.
The Gold Medal.—For his Paper on the Constant of Precession.

1851.
Feb. 15. Dr. Annibale de Gasparis.
The Gold Medal.—For the Discovery of three Planets, *Hygeia*, *Parthenope*, and *Egeria*.

1852.
Feb. 13. Dr. C. A. F. Peters.
The Gold Medal.—For his Papers on the Parallax of the Fixed Stars, and on the Constant of Nutation.

1853.
Feb. 11. John Russell Hind, Esq.
The Gold Medal.—For the Discovery of eight Planets, and other Astronomical Discoveries.

1854.
Feb. 10. M. Charles Rumker.
The Gold Medal.—For his Catalogue of 12,000 Stars, and for other Astronomical Services.

1855.
Feb. 9. Rev. W. R. Dawes.
The Gold Medal.—For his Astronomical Labours generally.

1856.
Feb. 8. Robert Grant, Esq.
The Gold Medal.—For his "History of Physical Astronomy."

1857.
Feb. 13. M. Schwabe.
The Gold Medal.—For his Discovery of the Periodicity of the Solar Spots.

1858.
Feb. 12. Rev. Robert Main.
The Gold Medal.—For his various Contributions to the *Memoirs* of the Society.

1859.
Feb. 11. R. C. Carrington, Esq.
The Gold Medal.—For his "Redhill Catalogue of 3,735 Circumpolar Stars."

1860.
Feb. 10. Professor P. A. Hansen.
The Gold Medal.—For his Lunar Tables.

1861.
Feb. 8. M. Hermann Goldschmidt.
The Gold Medal.—For his Discovery of thirteen of the Minor Planets, and other Astronomical Discoveries.

1862.
Feb. 14. WARREN DE LA RUE, Esq.
The Gold Medal.—For his Astronomical Researches, and especially for his Application of Photography.

1863.
Feb. 13. Professor ARGELANDER.
The Gold Medal.—For his Survey of the Northern Heavens.

1865.
Feb. 10. Professor G. P. BOND.
The Gold Medal.—For his work on the Comet of DONATI, and other Astronomical Researches.

1866.
Feb. 9. Professor ADAMS.
The Gold Medal.—For his Contributions to the Development of the Lunar Theory.

1867.
Feb. 8. W. HUGGINS, Esq., and Professor MILLER.
The Gold Medol.—For their Researches in Astronomical Physics.

1868.
Feb. 14. M. LE VERRIER.
The Gold Medal.—For his Planetary Tables.

1869.
Feb. 12. E. J. STONE, Esq.
The Gold Medal.—For his Rediscussion of the Transit of *Venus* in 1769, and his other contributions to Astronomy.

1870.
Feb. 11. M. DELAUNAY.
The Gold Medal.—For his "Théorie de la Lune."

1872.
Feb. 9. Signor SCHIAPARELLI.
The Gold Medal.—For his Researches on the Connexion between the Orbits of Comets and Meteors.

1874.
Feb. 13. Professor SIMON NEWCOMB.
The Gold Medal.—For his Tables of *Neptune* and *Uranus*, and other contributions to Mathematical Astronomy.

1875.
Feb. 12. Professor D'ARREST.
The Gold Medal.—For his work entitled "Siderum Nebulosorum Observationes Havnienses, institutæ in Specula Universitatis per tubum sedecimpedalem Merzianum, ab anno 1861 ad annum 1867," and other Astronomical Works.

1876.
Feb. 11. M. Le Verrier.
The Gold Medal.—For his Investigations of the Theories of *Jupiter*, *Saturn*, *Uranus*, and *Neptune*, and for his Tables of *Jupiter* and *Saturn*.

1878.
Feb. 8. Baron Dembowski.
The Gold Medal.—For his Researches on Double Stars.

1879.
Feb. 14. Professor Asaph Hall.
The Gold Medal.—For his Discovery and Observations of the Satellites of Mars, and for his Determination of their Orbits.

1881.
Feb. 11. Professor Axel Möller.
The Gold Medal.—For his Investigations of the Motion of Faye's Comet.

1882.
Feb. 10. David Gill, Esq.
The Gold Medal.—For his Heliometer Observations of *Mars* at Ascension, and for his Discussion of the Results.

1883.
Feb. 9. Dr. B. A. Gould.
The Gold Medal.—For his *Uranometria Argentina.*

1884.
Feb. 8. A. A. Common, Esq.
The Gold Medal.—For his Photographs of Celestial Bodies.

1885.
Feb. 13. Dr. W. Huggins.
The Gold Medal.—For his Researches on the Motions of Stars in the Line of Sight, and on the Photographic Spectra of Stars and Comets.

1886.
Feb. 12. Professor E. C. Pickering and Professor Charles Pritchard.
The Gold Medal, each.—For their Photometric Researches.

1887.
Feb. 11. G. W. Hill, Esq.
The Gold Medal.—For his Researches on the Lunar Theory.

1888.
Feb. 10. Professor Arthur Auwers.
The Gold Medal.—For his Re-reduction of Bradley's Observations.

1889.
Feb. 8. M. MAURICE LŒWY.
The Gold Medal.—For his Equatorial Coudé, his Method of Determining the Constant of Aberration, and his other Astronomical Researches.

1892.
Feb. 12. Professor G. H. DARWIN.
The Gold Medal.—For his work on the Tides and their Influence on the Figures and Motions of the Heavenly Bodies.

1893.
Feb. 10. Professor H. C. VOGEL.
The Gold Medal.—For his Spectroscopic and other Astronomical Observations.

1894.
Feb. 9. Professor S. W. BURNHAM.
The Gold Medal.—For his Discoveries and Measurements of Double Stars.

1895.
Feb. 8. Dr. ISAAC ROBERTS.
The Gold Medal.—For his Photographs of Star Clusters and Nebulæ.

1896.
Feb. 14. S. C. CHANDLER, Esq.
The Gold Medal.—For his Discussion of the Variation of Latitude, his work on Variable Stars, and other Astronomical Investigations.

1897.
Feb. 12. Professor E. E. BARNARD.
The Gold Medal.—For his Discovery of the Fifth Satellite of *Jupiter*, his Celestial Photographs, and other Astronomical Work.

LEWIS SWIFT, Esq.
The Hannah Jackson (née Gwilt) Gift.—For his Cometary Discoveries and other Astronomical Work.

1898.
Feb. 11. W. F. DENNING, Esq.
The Gold Medal.—For his Meteoric Observations, his Cometary Discoveries, and other Astronomical Work.